CHALLENGES FACING THE APPLICATION OF SUSTAINABILITY TO HOUSING IN SAUDI ARABIA

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BSc Architecture, Master of Project Management

Submitted in partial fulfilment of the requirements for the degree of

Doctor of Philosophy

Civil Engineering and Built Environment
Science and Engineering Faculty
Queensland University of Technology
2014

Keywords

case study analysis, Delphi method, housing for mid and low-income families, Islamic culture of Saudi Arabia, privacy, public awareness, Saudi architectural elements, Saudi building code, Saudi housing construction, Saudi housing case study, Saudi housing stakeholder, Saudi sustainable housing, Saudi renewable energy, semi-structured interview, sustainable housing

Abstract

Housing in the Kingdom of Saudi Arabia has transformed from that of a traditional 'Bedouin' society into new and advanced housing units, prompted by the use of modern architectural construction methods and design styles similar to those in many developed societies. However, Saudi Arabia's rapid population growth has caused a housing crisis, and the modern housing supply is neither sustainable nor efficient in meeting the cultural and environmental needs of the occupants. In addition, the lack of government regulations on sustainable housing forms another obstacle to the application of sustainable methods.

This research seeks a solution for sustainable housing in Saudi Arabia that adopts and respects the conservative Islamic culture of the community and the local environmental conditions. It identifies the key stakeholders in the Saudi construction industry and reveals their understanding of sustainability and how to apply it within the housing industry. This thesis also reveals the barriers to and critical success factors (enablers) for the application of sustainability to housing in Saudi Arabia. The final objective of this research is to understand the influence of Saudi Arabia's cultural and environmental factors on the development of sustainable housing.

To achieve these objectives, this study uses a combination of primary and secondary data. The primary data comprise a combination of semi-structured interviews with nine experienced practitioners, two rounds of Delphi studies involving 47 industry professionals, and three case study analyses. The secondary data support these findings by analysing and comparing relevant literature on sustainability and sustainable housing.

The experts who participated in the semi-structured interviews and the Delphi rounds agreed on the importance of the implementation of environmental, economic, socio-cultural and application factors for the successful development of sustainable housing in Saudi Arabia. Their responses reveal five high-level barriers to sustainable housing in Saudi Arabia: lack of public awareness, lack of stakeholders' interest, low levels of investment in sustainable housing, lack of financial incentives and lack of awareness from designing firms on how to design viable sustainable housing that incorporates Saudi conservative Islamic culture into the design. The stakeholders' responses also reveal five critical success factors: educating designing

firms on how to design sustainable housing, enlightening the public as to the advantages of sustainable housing, implementing new laws that enforce the utilisation of sustainable methods to housing construction, applying sustainable construction methods that meet the environmental comfort needs of residents and having the Saudi Government provide affordable sustainable housing units for low- and middle-income families

In addition, three case studies are used to demonstrate and validate how to implement environmental and cultural aspects in sustainable housing projects. Obstacles in the case studies include: an obligatory fence, which hinders the visual connection and community aspect of sustainable neighbourhoods, lack of recycling facilities, lack of adequate public transportation, lack of bicycle and pedestrian lanes and lack of awareness of local contractors of sustainability practices.

This research recommends that Saudi housing adapts to both the unique Saudi conservative Islamic culture and the local environment by utilising passive cooling and incorporating a courtyard design. Applying these design methods will ensure that the unique cultural aspects of Saudi Arabia as well as the other sustainability aspects are upheld in future housing projects.

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List of Publications

Susilawati, C. & Al Surf, M. (2011). *Challenges facing sustainable housing in Saudi Arabia: A current study showing the level of public awareness*. Paper presented at the 17th Pacific Rim Real Estate Society Conference, Bond University, Gold Coast, Australia. Retrieved from http://eprints.qut.edu.au/46328/

Al Surf, M., Susilawati, C. & Trigunarsyah, B. (2012). Analyzing the literature for the link between the conservative Islamic culture of Saudi Arabia and the design of sustainable housing. In F. Pour Rahimian, R. Ibrahim, J. Goulding & A. A. A. Abang (Eds.), *Proceedings of 2nd International Conference on Socio-Political and Technological Dimensions of Climate Change, Hotel-Marriott Putrajaya* (pp. 3–16). Selangor: University Putra Malaysia Press. Retrieved from http://eprints.qut.edu.au/55235/1/STDCC2012_Al_Surf_Susilawati_Trigunarsayah.pdf

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List of Abbreviations

CO_2	Carbon Dioxide
CSFs	Critical Success Factors
GBCI	Green Building Certification Institute
GCC	Gulf Cooperation Council
KSA	Kingdom Saudi Arabia
LEED	Leadership in Energy and Environmental Design
MENA	Middle East and North Africa
MOHPW	Ministry of Housing and Public Works
MOMRA	Ministry of Municipal and Rural Affairs
QSAS	Qatar Sustainability Assessment System
SAR	Saudi Riyal
SBC	Saudi Building Code
SBCNC	Saudi Building Code National Committee
SEEC	Saudi Energy Efficiency Centre
SGBC	Saudi Green Building Council
UAE	United Arab Emirates
US	United States
USGBC	United States Green Building Council

Statement of Original Authorship

The work contained in this thesis has not been previously submitted to meet requirements for an award at this or any other higher education institution. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made.

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Date: 12 November 2014

Acknowledgements

First and foremost, I would like to thank the Almighty Allah for his grace and giving me the strength and knowledge to complete this thesis.

Second, great gratitude and appreciation to my wonderful supervisory team: my principle supervisor, Dr Connie Susilawati, and my associate supervisor, Associate Professor Bambang Trigunarsyah. Without their continuous support, encouragement and guidance I would not have accomplished this great achievement.

I am utterly grateful to my father and mother, Saied and Samira, for their heart-warming and generous continuous support throughout my studies and through many hardships I have faced during my candidature. So thank you, Mom and Dad, for everything—you made believe I can do it.

I also would like to extend my sincere gratitude and love to my lovely wife, Alaa, and my daughter and son, Balqees and Abdul-Aziz, for their never-ending support and continuous love. They waited for me on the weekends and in lonely nights to finish this thesis. So thank you, from the bottom of my heart.

I would like to also thank my brother and sister, Faris and Zuhrah, for their cheering and encouragement. Thank you to my extended family for your prayers and thoughts.

Last but not least, I would like to send out a special thank you to all who participated in my thesis and gave me input or data to reach the final product I have today, and a special thank you to my editors "Elite Editing" for their editing and proofreading of the whole thesis that was restricted to Standards D and E of the *Australian Standards for Editing Practice*.

Chapter 1: Introduction

1.1 RESEARCH BACKGROUND

Housing can be seen as the most vital long-term investment one can make for their family. This is because housing provides security, privacy, and stability for the whole family. Further, a single house as part of a housing project can be seen as a value by which the family living in that house are categorised by and it can denote social prestige (Opoku & Abdul-Muhmin, 2012). In traditional societies, housing simply meant shelter. In these societies, housing was emphatically efficient, compatible to the surrounding environment and socially fitting (Mubarak, 1999). In other words, shelter had a close relationship with survival. However, with the development of human society into what it has become today, housing and land have evolved into something more than a necessity for survival. They have become somewhat of a statement of social standing instead. People perceive land and housing as social resources rather than market commodities. As a result, the provision of housing has become more complex rather than simple. Various factors dictate efficient housing designs that can cater for both cultural and social needs. Some factors include economic resources, government policies, and the level of institutional and technological advancement, among others (Mubarak, 1999).

Economic prosperity and urban development in the Kingdom of Saudi Arabia has rocketed in the past two to three decades. The discovery and commercial exploitation of oil in the 1930s coupled with the rising market demand in the 1970s in the Kingdom of Saudi Arabia, has transformed traditional societies into lifestyles similar to those in many developed societies (Mubarak, 1999). This transformation has resulted in an urban sprawl in all major cities in Saudi Arabia. Saudi Arabia's urbanisation level, according to the Central Department of Statistics and Information (2010), is at 82.3 per cent of total population and rate of urbanisation is 2.38 per cent annual rate of change. The population estimate in 2013 for Saudi Arabia is 29.20 million, which includes 32.1 per cent non-nationals (Ministry of Economy and Planning, 2013b). The 2012 census indicated the five largest urban areas in Saudi Arabia, according to administrative regions, are Riyadh, 7.310 million; Makkah, 7.472 million; Eastern Region, 4.414 million; Medina, 1.911 million (Ministry of Economy and Planning, 2013b).

In developing countries like Saudi Arabia, which experience such a rapid rate and ratio of urbanisation, government departments should implement the concept of sustainability and enforce laws and regulations. In the case of Saudi Arabia, as well as many other developing countries, economics is not the only issue. The quickly diminishing availability of resources must also be considered. Potential methods that may be applied to sustainable housing in Saudi Arabia include the full use of the site design, passive solar design, natural light and ventilation. Kennedy and Katoshevski (2007) accentuate not only the pressures experienced by the region from extended population growth, but warn of the possible change in regional character and identity threat, due to the steady and dangerous increase of resource consumption. They cite that an obvious culprit of this evolvement is the defaulting to air conditioning for design solutions, rather than attempting more natural and area-adaptable solutions for building comfort.

Society can benefit greatly from increasing urbanisation, particularly if that urbanisation occurs at a high rate in a short time span. Consequential to the high rate of urbanisation inflicted upon Saudi Arabia within such a short time span are many negative afflictions. Countries currently undergoing urbanisation developments and expansions, according to Henderson (2002), are facing more challenges than those countries that are considered already developed during their years of development and expansion. This is because the developed countries took much longer in their growth stage, in which urbanisation expanded, compared to what is occurring now in regions such as Saudi Arabia—rapid urbanisation in a much shorter time span.

This tremendous growth caused strain in various sectors of the Saudi Arabian economy (Mubarak, 1999). The first sector in the Kingdom to experience the strain was the housing sector, where almost 11.2 million Saudis are estimated to live in rented accommodation: 2.2 million rental units (Central Department of Statistics and Information, 2010). A shortage of housing has resulted due to sheer increases in rental prices (Edwards & Turrent, 2013). The tremendous increase in demand for new and advanced housing units prompted the use of modern architectural construction methods and design styles. Mubarak (1999) suggests further that the prominent modern styles include the Western-styled villa and multiple story apartments. However, the problem of housing shortage persisted, especially among low- and middle-income earners. Even when one managed to secure housing, it was neither sustainable, nor efficient in the provision of cultural needs of the occupants (Gamboa, 2008). Designing sustainably, according to Hamed (2003), is no longer a luxury addition to a building, it is now vital to the survival of the present generation and those yet to come.

A housing crisis exists in Saudi Arabia and especially in Jeddah, argues Abdulaal (2011). The draft of the Jeddah Strategic Plan indicates the severe shortage of adequate housing for low- and middle-income residents. Although there are no sound or scientific statistics to support this claim, continued growth of unplanned settlements is evidence enough of this increasing shortage of adequate housing for this sector of the public, with nearly 1 million residents currently living in unplanned areas of Jeddah:

> It was estimated that the supply of housing units in Jeddah included 697,000 units in 2007, and there is currently a shortfall of 283,000 homes in Jeddah, including 80,000 in the low-income sector. The Jeddah Strategic Plan calls for 151,600 new units to be built to accommodate those people currently living in unplanned settlements, with a further 47,500 units to be built annually to meet the demands of population growth. With regard to future requirements, the strategic plan foresees the need for 953,000 units, and an investment of US$640 billion, over the next 20 years. (Abdulaal, 2011, p. 43)

Compounding the growing housing crisis in Saudi Arabia is the lack of regulations from the Government sector concerning the application of sustainable methods:

> There are no regulations, or compulsory building codes, that incorporate the principles of sustainable architecture in the country. It has been argued by many scholars that setting a coherent set of these codes and standards is one of the most important and cost-effective ways to promote the widespread of sustainable practices, especially with regard to reducing household energy and water consumption. (Karam, 2010)

Saudi Arabia is one of the top environmentally challenged countries around the world. According to Al Fadl (2010), Saudi Arabia's ecological footprint is roughly twice the world average, standing at 4.5 hectare of ecological footprint per person. Not only that, but among the environmentally challenged countries of the world, the country is ranked in the top 20. The climate in Saudi Arabia is generally harsh, dry desert conditions with extreme temperature differences ranging from -11^{o}C to 51.1^{o}C (Piccolo, 2010).

The Saudi culture is defined by the teachings of Islam and is governed by the teachings of the Qur'an and the Hadith (Sayings) of the prophet Mohammed (Peace Be Upon Him) state. In Islam, the Holy Quran and the Sunnah (Prophet Mohammed's deeds and sayings) are the guidance for all Muslims in every aspect of their daily life. Therefore, it is imperative that what is learned from the Holy Quran and the Sunnah is reflected in the essential design of Muslims' houses. The culture of Saudi residents is a family-oriented, where traditionally three to four generations may live under one roof. The elderly are respected and are considered the wise members of the family and the head of the family (North & Tripp, 2009). With this multigenerational household in mind, it is evident that the Saudi house would be larger in scale as opposed to those where a single family live in a two bedroom unit or similar.

Segregation is also an important Muslim value, which housing design should incorporate. Muslim culture advocates for segregation, especially women, from public life in the streets. This fact is true in Saudi Arabia where the segregation between male and female sections in a house is typical and mandatory to the Islamic ways of living. Privacy, according to Mahmud (2009), is paramount in the design of housing for occupants ascribing to the Muslim culture. In this culture, privacy, especially for women, is extremely imperative. Privacy is crucial in the design of a Saudi house, and the concept of privacy is observed in three different areas as stated by Daneshpour (2011)—privacy between dwellings and neighbours as well as the street, privacy between sexes, and privacy between individual family members of a dwelling.

For a long time, the delivery of housing products to Saudi residents has utilised a traditional approach because demand for housing in Saudi Arabia emerged due to variation in level of income and population growth (Mahmud, 2009). It regards cost reduction as the main factor and disregards the other factors (Salama, 2006). The designers, according to Sidawi (2008), have neglected the Saudi's cultural norms, lifestyles and traditions. Incorporating these dimensions, as argued by Sidawi (2008), into housing design decreases the overall cost of the product and its lifetime cost (maintenance and running cost, renovation and alteration expenses). This would affect property life and the user's life positively. Therefore, housing designers bear the responsibility of providing tailored and sustainable housing that meets user needs, while users bear the responsibility of using the houses in a sustainable manner (Gamboa, 2008).

1.2 RESEARCH PROBLEM AND RATIONALE

Sustainability has been identified worldwide as a necessity and the application of sustainable construction methods is vital for the survival of natural resources for future generations. This was defined by the United Nations World Commission on Environment and Development (UNWCED) as that which 'meets the needs of the present without compromising the ability of future generations to meet their own needs' (1987). Housing demand in Saudi Arabia, as in many developing countries, is increasing rapidly and the housing construction market is facing immense shortages of adequate housing (Al Otaibi, 2004). Sustainable housing is still considered a luxury option and is mainly provided for those who have the financial capacity to pay for it. This concept is mainly the result of lack of public awareness of the benefits and cost of applying sustainability measures and techniques to housing construction (Susilawati & Al Surf, 2011).

Several challenges are present in the development of sustainable housing in Saudi Arabia, including environmental, economic, and socio-cultural factors, in addition to application challenges. Saudi Arabia has unique challenges facing the application of sustainability to housing, but as the country is under development, it is vital to develop research, such as this research, which can guide Saudi stakeholders to make sustainable decisions related to housing construction. Therefore, it is the rationale of this research to address the critical success factors (or enablers) and barriers facing the application of sustainability to housing construction in Saudi Arabia, and the adaptation of the unique conservative Islamic culture of Saudi Arabia into the design of sustainable housing.

1.3 RESEARCH QUESTIONS, AIM AND OBJECTIVES

Sound empirical research, according to (Eisenhardt & Graebner, 2007, p.26), 'begins with strong grounding in related literature, identifies a research gap, and proposes research questions that address the gap'. In view of the research problem and rationale, the research questions that will be investigated are:

1. What is the current understanding of key stakeholders in the Saudi construction industry regarding sustainable housing?

2. What are the critical success factors (enablers) and barriers affecting the development of sustainable housing for low- and middle-income families in Saudi Arabia?
3. How do the cultural and environmental factors of Saudi Arabia influence the development of sustainable housing?

In view of the research questions, it is the aim of this research to develop a model for the successful implementation of sustainability to housing in Saudi Arabia. This model incorporates specific cultural, economic, environmental and application factors of the country. The following objectives are designed to achieve the above aim:

- to identify the key stakeholders in the Saudi construction industry and their understanding of sustainable housing
- to identify the critical success factors and barriers for the development of sustainable housing in Saudi Arabia
- to understand the influence of Saudi's cultural and environmental factors in the development of sustainable housing.

Additionally, it is the objective of this research to materialise recommendations for Saudi stakeholders, including government, regional municipalities, academics and the construction industry, as to the need of adopting sustainable procedures for construction. Another objective is to illustrate the economic, environmental and social benefits of applying sustainability to the housing construction industry.

1.4 RESEARCH SCOPE

The research examines the importance and advantages of applying sustainable methods to housing construction in general. This is done by assessing developed countries that have adopted the concept and have reaped the benefits from applying this method of construction. The aim will be identifying the critical success factors and barriers for the development of sustainable housing and understanding the influence of Saudi Arabia's cultural and environmental factors on the development of sustainable housing. The scope of the research is mainly on how to achieve sustainable housing in Saudi Arabia, especially in a conservative Islamic community.

1.5 RESEARCH METHODOLOGY

In order to achieve the outlined objectives in this research, the data collection methods used include a public online survey, semi-structured interviews, two Delphi rounds, and three case study analyses. The research focuses on input from experts in the field of construction in Saudi Arabia, mainly because of lack of public awareness. The public at this stage in time is unaware of the issue being investigated. Two online surveys, one conducted at the beginning of the PhD and the second conducted at the end of the four-year PhD, showed that more than 67 per cent of the public do not even know what sustainable housing means and more than 88 per cent are unaware of any sustainable projects in the country. Hence, the focus is primarily on the experts who can give answers to fill the research gap. Figure 1.1 illustrates the research methods and data collection methods used in the thesis.

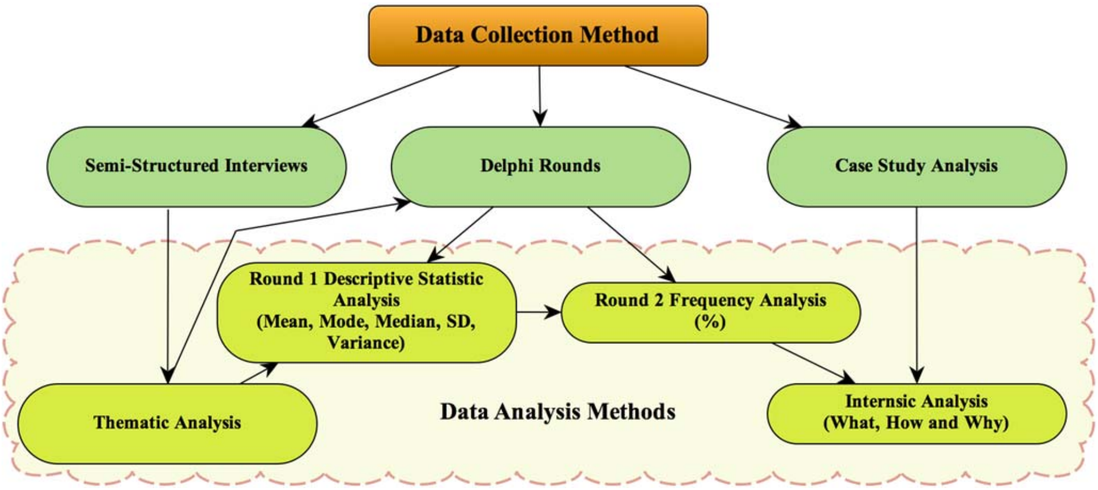

Figure 1.1. Research methods.

Once the data are collected and evidence is shown as to the importance of the application of new sustainable construction methods that should be applied to the housing industry in Saudi Arabia, a model is generated. This model can be used in the development of a sustainability rating system for housing development in a conservative Islamic society in Saudi Arabia. The generated model focuses on all aspects of sustainability: environmental, economic and socio-cultural. Great emphasis is placed on the cultural issues of the rating system, applicable in the Islamic conservative society of Saudi Arabia, where it can also be economically viable for low- and middle-income families.

1.6 THESIS OUTLINE

The research is based on an inductive approach, where the research questions are answered by investigating the current literature as displayed in chapters 2 and 3. The investigation is then built on the research methodology as explained in Chapter 4. The methodology is expanded by utilising three data gathering methods, as detailed in chapters 5, 6 and 7. Chapter 5 discusses the semi-structured interview, Chapter 6 discusses the Delphi rounds and Chapter 7 discusses the case studies. Chapter 8 discusses the findings from the three data collection methods, as they answer the research questions. Finally, Chapter 9 concludes the research by elaborating on the contributions to the industry and to academic knowledge, and discussing the limitations of the research. This culminates in recommendations for future research.

1.7 SUMMARY

This research has outlined the need to know the current understanding of the key stakeholders involved in the housing construction industry in Saudi Arabia. It defines the critical success factors (enablers) and barriers of applying sustainable construction methods to housing in Saudi Arabia. A discussion has been initiated for the importance of incorporating the unique conservative Islamic culture of Saudi Arabia into the design of sustainable housing and how it can be developed for low- and middle-income families.

Chapter 2: Housing and Sustainability in Saudi Arabia

2.1 INTRODUCTION

Saudi Arabia is one of the Gulf Cooperation Council (GCC) countries: Qatar, the United Arab Emirates (UAE), Kuwait, Bahrain, Saudi Arabia and Oman. It is located in the Middle East where Jordan, Iraq and Kuwait border it from the north. UAE, Qatar, Bahrain and the Arabian Gulf border it from the east. Yemen and Oman border it from the south, and the Red Sea borders it from the west (see Figure 2.1).

Figure 2.1. Geographical location of Saudi Arabia (CIA 2003).

The GCC in general and Saudi Arabia in particular, have their cultures firmly based in the religion of Islam. Unlike many other societies of the world, this region's culture revolves around the tenets of the religion, more so than a secular life. In addition, to the religion, the region has a harsh arid climate, which plays a decisive role in how dwellings are designed and used. It is these elements as well as the economic nature of the society that need to be taken into consideration when promoting the ideal of sustainability in the housing sectors.

The GCC region in general and perhaps Saudi Arabia in particular, have witnessed an immense burst in population growth in a short span. This has resulted in rapid growth of urban areas, with quick development of modern style housing that is foreign to the environment, and ultimately not environmentally friendly, nor of a sustainable nature.

In addition to this rapid growth and tendency away from the traditional forms of construction for housing, which implemented much of the natural resources and conformed to styles emanating and conforming to the cultural needs of the people, is the question of the role of the Saudi Government. The policies relating to building codes and regulations, with emphasis on the importance and validity of employing a method of sustainability rating systems such as the Leadership in Energy and Environmental Design (LEED), will be discussed in detail in section 3.4.

In fact, this rapid urban population growth and non-environmentally friendly housing developments are compounded by the need to adhere to the religious and traditionally cultural confines. In addition, the need to instil and enforce building codes and regulations employing systems of sustainability ratings, present some major challenges in order to introduce sustainability to the housing sector. This will be explored in detail in the following sections and subsequent chapter.

2.2 SUSTAINABLE DEVELOPMENT

Housing and sustainability can coexist with each other indisputably and many developed countries have reaped the benefits from applying sustainability measures to housing in their countries. It is imperative, therefore, to understand explicitly what sustainability is and entails, as well as emphasise why it is necessary to develop sustainability in a housing sector where no such concept was previously employed.

2.2.1 Sustainability Defined

There are more than 300 definitions of sustainability worldwide, including the most used definition by the World Commission on Environment and Development (WCED), which defined sustainability as that which 'meets the needs of the present without compromising the ability of future generations to meet their own needs' (1987). Sustainability, according to Phillis (2001), is a concept of which the scientific definition and exact measurements are lacking wide acceptance, rendering it inherently vague. Further, Hansen and Zenobia (2011, p. 441) report the definition of sustainability in terms of the 'three Es' and state:

> The Brundtland Report also pointed out the importance of evaluating actions in terms of what has been called the three E's: Environment, Economy and Equity. The three E's force us to examine the cause and effects of our actions in relationship to the systems of the Earth and also to examine issues of justice—both economically and socially—for our fellow humans.

The definition of sustainability according to Chiu (2012) has been further broken down into economic, environmental and socio-cultural definitions. Economic sustainability of housing is 'The extent to which housing production processes can be sustained to satisfy present and future housing needs and demands' (Chiu, 2012). Environmental sustainability of housing is:

> The extent to which the environmental impact of housing activities is reduced, thereby conforming to levels which are within the capacity of the natural environment to carry, such that the environmental quality of the surroundings is improved to enable healthy living. (Chiu, 2012, p. 91)

Finally, the socio-cultural sustainability of housing is:

> The extent that social and cultural values and practices support environmentally friendly housing, that acceptable housing is available and affordable, and that housing contributes to social well-being and cultural development. (Chiu, 2012, p. 91)

Sustainability, when applied to housing, is a broad concept due to the numerous definitions attached to it. However, it can be explained as that which takes into consideration durability (for the long haul), consideration for the natural environment (not adding to excess waste), and proving eventual economical advantage, even if not at the onset of production. Hence, from the definitions listed above, this thesis adopts that sustainable housing's definition is that which can have minimal impact on the environment, is affordable, enhances the productivity of its occupants, has clear benefits that can be understood by the average person and respects the local culture. Figure 2.2 illustrates the triple bottom line of sustainability. (Chiu, 2012, Hansen and Zenobia, 2011, Phillis, 2001, World Commission on Environment and Development, 1987)

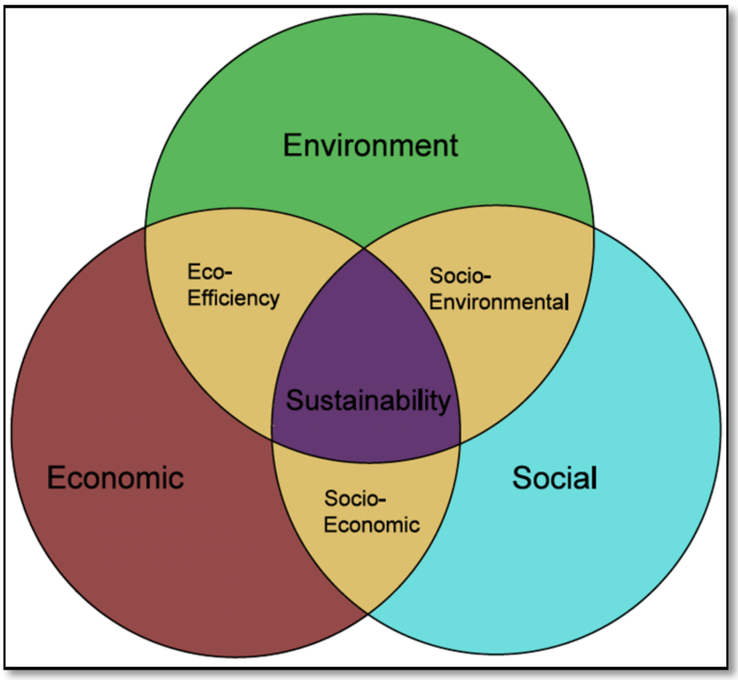

Figure 2.2. The triple bottom line of sustainability (Vanclay, 2004).

2.2.2 Sustainable Housing Development

Sustainable development, according to Berke (2002), is the result of the relationship and interconnectedness of environmental, economic and social factors, that results in practices and actions that benefit both present and future generations. As with everything else containing the reference to 'green', this term has evolved from the growth of awareness to the need for efficiency of resources and safety on the environment (Ross, 2005). Although various individuals worldwide have promoted the concept of sustainable housing, it is even more convincing that success is promised when an international organisation such as the WCED gives its stamp of approval. The WCED (1987) adds that within the definition of sustainability it contains two fundamental concepts:

- The concept of 'needs', in particular the essential needs of the world's poor, to which overriding priority should be given.

- The idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs.

The logical general benefit and usage of housing was argued by Colvin (2006). Colvin states that it is the provision of general lodging and shelter in addition to a safe-haven for rest and family life or simple enjoyment of the most necessities of eating, sleeping and refreshing oneself. She adds that without proper housing, it is difficult, if possible at all, to accomplish more luxurious amenities to life, such as studying, working or the maintenance of good health. The pure essence of the term 'sustainable housing' has been argued by Pett (2004), that it is generally a rephrasing of the issue that is merely a type of housing that intends to obey the principles of sustainable development. Further, Miller and Buys (2013) stated that the focus of sustainable housing research is the implementation or evaluation of energy efficiency inputs and outcomes. Further focuses on sustainable housing include climatic and cultural contexts (Birkeland, 2008; Miller & Buys, 2013). A decent home, according to Edwards and Turrent (2013), is crucial for personal wellbeing, social cohesion and self-dependence. Sustainable housing development, according to Chiu (2012, p. 91), is 'Housing development that meets the housing needs and improves the housing conditions of this generation without compromising the ability of future generations to do the same'.

Some of the major problems for the development of sustainable housing include vagueness of defining what the term means and agreeing on a single definition where the issues that are interrelated are addressed if progress is to be made (Pett, 2004). The very use of the word 'sustainability', according to Salama (2002), confuses people, although it has been around since the 1950s. However, the terms that were used since the 1950s evolved to become 'Good Design', 'Energy

Conscious Design' in the late 1960s, 'Energy-Efficient Design' in the 1970s, 'sustainability' in the late 1980s and 1990s, and in the years 2001 and 2002, the word was replaced by 'high performance buildings'. In Salama's argument, sustainability was considered 'a negative impact' because the language used to define sustainable housing is confusing for the public, and the term is just a rephrasing of the traditional architecture that has been forgotten along with its value.

Sustainable housing development in Saudi Arabia therefore, should be no different than the statements mentioned above. The development must meet the needs of the current generation without compromising the needs for future generations to meet their own needs. Additionally, those needs that must be met should improve the productivity of the residents and meet their special and unique cultural requirements. The involvement of the public and simplifying the terminology for them to understand the benefits of adopting sustainable methods will increase its application in the country and create a better future for the coming generations. Having sustainable projects visible to the public, who can test and experience the difference to non-sustainable projects, will help clear any misconceptions they may have on the meaning of sustainable development.

2.2.3 Why Sustainable Housing?

Sustainable housing reduces the overall impact on the environment. It also saves money by utilising several methods and techniques, such as energy saving techniques, building materials that deflect sunlight and insulation that reduces the cooling load of the house. Sustainable 'green' buildings, according to Mahroum (n.d.), decrease energy consumption by approximately 30 per cent, water consumption by 30 per cent to 50 per cent and expenses by 50 per cent to 90 per cent. This explains the increasing global pressure on the construction sector—a pressure that requires people to use concepts that are not only energy efficient, but also environmentally safe. The existence of regulation frameworks and government incentives has evoked extensive interest in the use of sustainable and green building technology (Sidawi & Meeran, 2011). In fact, governments are acknowledging the need to foster construction concepts that are eco-friendly. Such techniques help to:

- save energy and conserve resources (water and other natural resources)
- reduce pollution, waste and environmental degradation
- implement comfortable and healthy living environments (Al Rimmawi & Bhardwaj, 2007).

2.2.4 Affordability and Sustainable Housing (Economic Sustainability)

Sustainability measures in housing can reduce the overall costs of the full lifecycle of a house. As discussed in the previous section, a sustainable house can achieve a 30 per cent reduction in energy, up to 50 per cent reduction in water consumption and up to an astounding 90 per cent in cost savings. It is clear what sustainable housing is by looking at the savings it can achieve in energy, water and overall costs. However, the question remains as to what affordable housing means. Affordable housing units, according to Smith (2012, p. 7), are 'Dwellings built specifically for those whose income denies them the ability to purchase or rent on the open market'. Further, Milligan and Gilmour (2012, p. 58) have also defined affordable housing:

> Affordable housing is housing that is provided at a rent or purchase price that does not exceed a designated standard of affordability. Affordability is usually defined by measuring whether housing costs exceed a fixed proportion of household income and/or whether household income is sufficient to meet other basic living costs after allowing for housing costs.

In order for housing to be classified as affordable, it needs to be affordable for low- and middle-income families; the line of affordability has to be drawn by the local government to identify what is affordable and what is not. Further, affordability and sustainability can coexist; a sustainable house that is affordable for low- and middle-income families is the ideal solution and can create a perfect setting for a family with limited income that has minimum impact on the environment and reduces the overall cost of constructing and maintaining the house.

A more detailed discussion in section 2.4.5 reviews the economic factors that challenge the application of sustainable housing in Saudi Arabia, where an astounding 70 per cent of the population is renting. Even worse, the rented accommodation is not sustainable. Further, the minimum required monthly salary for a Saudi national to buy a decent house should be SAR 9,209. A study conducted by a Saudi construction company, which gathered information from over 30 real estate developers in the city of Riyadh, found that an average detached house for a single family in the city of Riyadh would cost around SAR 1,608,082 (Affordable House Co., 2012). The study shows that the percentage of Saudi families that can afford to buy this house is around 56 per cent of the total population of the city of Riyadh. With almost half of the population in the capital city unable to afford to buy or build a house in that budget range, the issue of providing adequate affordable and sustainable housing is vital.

2.2.5 Sustainable Urbanisation

Sustainable urbanisation, according to Miranda and Marulanda (2001), is the condition in which growth is accompanied by 'harmonic development with the environment'. This is where optimum living conditions are accessible within the realms of equal opportunity for both sexes, by the virtue of services and habitat conditions, all the while keeping excessive pollution and the destruction of resources (water, soil, air, flora and fauna) to a bare minimum. A key point for sustainable construction, according to Miranda and Marulanda (2001), is to reduce energy consumption and wastage, preserve the natural environment by minimising alteration to it, and preserve all living forms of that natural environment. Yet Roy (2009) warns that as the total population of the world is now in excess of 6 billion, with more than 50 per cent of this population residing in urban areas, the rate of urban population by 2025 will exceed two-thirds of the total global population. Further, Roy (2009) shows concern for the deteriorating state of fast growing cities in ill-prepared areas. He warns of explosive population growth, based upon the projections that 90 per cent of new urbanites are located in developing countries, which are characterised by low states of economic development combined with a poor environmental health.

Active cooperation of different specialties and stakeholders as argued by Roy (2009), including the civil sector of society, is needed to achieve sustainable urbanisation. Additionally, The UN Sustainable Cities Programme (SCP) points out that stakeholder involvement at various stages of successive and overlapping activities is what defines sustainable urbanisation. The ultimate goal of this process is to achieve a balance between the aspects of the technological, socio-political, economic and environmental differentiations (United Nations Environment Programme, 2000). A system of policy initiation argued by Jepson (2001), which incorporates a combination of personal opinion provided by citizens by means of participation, coupled with scientific insights provided by scientific analysis or other objective expertise, is necessary in order to achieve the desired effect of sustainable urbanisation.

However, what are the actions required to succeed in building a sustainable urban environment? How is sustainable urbanisation achieved? Miranda and Marulanda (2001) affirm that what is required to avoid irreparable and excessive damage to the environment is affirmative action, such as the initiation and actualisation of a variety of clean techniques and technologies to be implemented into the construction stages. An essential part of the urbanisation process is defining and utilising existing local resources as a contribution to the development of the project, as well as avoiding over-usage and waste, which only depletes the supplies.

2.2.6 Sustainability Measures

Sustainability measures need to comply with the three bottom line elements of sustainability, which include economic, environmental and socio-cultural factors. Homes and commercial buildings use large amounts of energy for heating, cooling, lighting, and other functions, which incur an economic burden as well as having a direct effect on the environment. Sustainability and 'green building' techniques can allow new and existing buildings to use less energy to accomplish the same functions, leading to fewer greenhouse gas emissions. There are several techniques to improve building energy efficiency, including:

- better insulation
- more energy-efficient heating, cooling, ventilation, and refrigeration systems
- efficient fluorescent lighting
- passive heating and lighting to take advantage of sunlight
- the purchase of energy-efficient appliances and electronics. (Green Building Academy, 2014).

Sustainability is not a slogan; it is a life style, and a necessary one at that. Sustainability can reduce the amount of carbon dioxide (CO_2) emissions, which are estimated to reach a peak in 2025 (Ting, Mohammed & Wai, 2011). The literature presents numerous discussions on the issue of energy and conserving the consumption of energy around the world and in developing countries in particular (Bhattacharyya, 2009; Erdmenger et al., 2009; Fenerty-McKibbon & Khare, 2005; King Abdullah University of Science and Technology (KAUST) Industry Collaboration Program, 2013; Khare, 2005; Kikuchi, Bristow & Kennedy, 2009; Liao, Yao & Chin, 2008; Malla, 2009; Say & Yucel, 2006; Schumacher, 1985; Ting et al., 2011). The bottom line is 'to become a sustainable society, the world must consume less energy' (Ting et al., 2011). Energy is not only essential to cater to human needs and allow them to maintain their activities including social, cultural, technological, medical, and economic development. It is also essential to ensure protection of the environment and prevention of pollution. Arab countries, and specifically GCC countries, consume vast amounts of energy and water. That is why it is important to address this issue in the next section and highlight the challenges facing the unique climatic, environmental and socio-cultural aspects of these countries. The discussion then focuses on the high energy and water consumption in the largest GCC country, Saudi Arabia.

2.3 UNIQUE SUSTAINABLE CHALLENGES IN GCC COUNTRIES

Perhaps more so than in many other areas of the world, the GCC region is plagued with unique challenges when it comes to the question of employing sustainability in the housing sector. Not only is the region well known for its extremely harsh arid conditions, it also shows evidence of a very high imprint of energy and water consumption per capita compared to other more naturally endowed and even more highly populated areas of the world. This will be exemplified in the upcoming sections. It is therefore imperative to shed some light on the unique challenges, which include economic, environmental and socio-cultural challenges, facing GCC countries in general, and Saudi Arabia in particular.

2.3.1 Sustainability and the Preservation of Natural Resources

With all the various definitions available in the literature on sustainability, one main concept is found to be common among all the definitions: the importance of the preservation and managed use of natural resources for the sake of future generations. Preservation of natural resources can be achieved through the application and adaptation of sustainable construction methods. The application of sustainability for the purpose of natural resource preservation has numerous economic, environmental and socio-cultural advantages. Developing countries are still under development and that gives them the advantage of applying the concepts and applications of sustainability while projects are still under construction. Conversely, developed countries have to either demolish and rebuild with new sustainable standards or renovate, which is much more difficult.

Global warming is prevalent and is no longer a myth; natural resources are getting scarcer every day. Developing countries are facing numerous challenges aside from depleting natural resources. For example, the uprising in the Middle East region, which started in 2010 with the unrest in Tunisia followed by Libya, Syria and Egypt, is causing more chaos than before, which directly affects the economic and socio-cultural scales of those countries (Dalacoura, 2012). These challenges put more stress on the development of the region and further delay the progress of sustainability in the construction industry.

The Middle East and North Africa (MENA) region is considered one of the driest regions in the world, where natural renewable water sources account for 1.2 per cent of the world's renewable water resources (Andersen, 2014). Two factors are adding pressure on water sources in the region: rapid population growth and high urbanisation. Some countries in the region can afford desalination plants, such as the Kingdom of Saudi Arabia (KSA); others are forced to drawing on aquifers faster than they can be naturally replenished, or overdraw on non-renewable water resources (Andersen, 2014).

The world population is aware of the current climate change and global warming. The issue is no longer a myth—it is a reality. MENA opinion polls show that 80 per cent of the population consider this matter to be very serious (Andersen, 2014). The world population is consuming natural resources much faster than the planet can replenish. Natural resources can be classified into two categories:

renewable and non-renewable. Renewable natural resources mean that by the time they are used, new regenerated resources are made, such as solar and wind. Non-renewable natural resources are sources that are impossible to regenerate in a timely manner, such as oil and mineral ore.

2.3.2 Energy and Water Consumption in GCC Countries

The most challenging factors affecting the GCC economy and natural resource levels are energy and water. A vicious cycle exists in the GCC region. Water is scarce in the region, so desalination plants produce fresh water for the region. These desalination plants consume large amounts of energy, powered by non-renewable energy. GCC countries combined control 40 per cent of the world's known oil reserves and 23 per cent of proven natural gas reserves. According to Kinninmont (2010), by 2020, world dependency on GCC energy exports will grow. So, in the minds of current generations, why should the GCC population think about or even worry about conserving energy? According to the United Nations Environment Programme (2009), 'Buildings are responsible for more than 40 per cent of global energy use and one-third of global greenhouse gas emissions, both in developed and developing countries'. The total primary energy consumption was 510.551 quadrillion Btu in 2010 and the total electricity net consumption was 5002.912 billion kilowatt-hours globally. From this huge amount of energy consumption, the total CO_2 emissions from the consumption of energy was 32,578.645 million metric tons in 2011 (US Energy Information Administration, 2013). This is demonstrated in Figure 2.2, in which the GCC nations' rate of energy consumption is visualised in a graph of the forecast from 2000 to 2020.

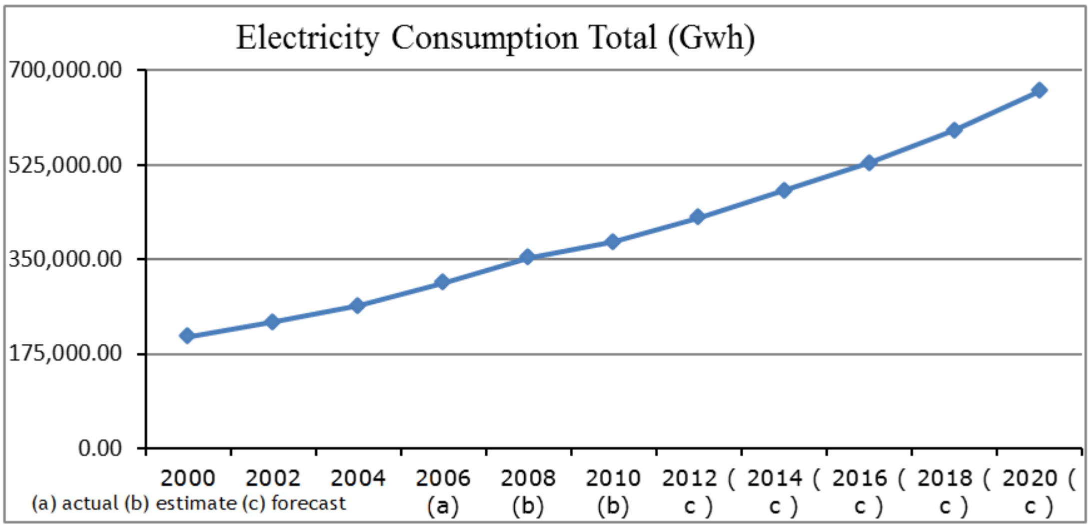

Figure 2.3. Energy consumption over time in GCC (GWh) (Kinninmont, 2010).

The need of the hour is energy conservation, according to Ting et al. (2011), and this is the bottom line that needs to be clear and understood by all energy consumers. New technologies and techniques have been developed to help reduce the daily consumption of energy and water. Achieving sustainability ratings in a building using any of the world's known rating systems, such as the United States (US) Green Building rating system LEED, requires a building to comply with energy and water conservation requirements. For example, the minimum LEED requirement to get a building certified in terms of energy efficiency is a 10 per cent improvement in the proposed building performance in a new building, or a 5 per cent in a major renovated project (US Green Building Council, 2014a). It is also a LEED requirement to have an on-site renewable energy source.

GCC countries, according to Kinninmont (2010), will have a great task ahead of them to cope with the increasing population and their demands of basic supplies such as food, electricity and water; it is estimated that the population will soar by 30 per cent to breach 50 million over the next decade. Current generations are not the only ones affected by these soaring numbers and high demands. Post—-2020 generations will also feel the effect of today's high demand. With the forecasted increase in population in the GCC region, the economic forecast is also heading in a positive direction. This economic increase might seem an advantage to the region but it brings with it several risks, such as power shortages and high prices in general, for food specifically. However, with these risks taken into consideration by GCC countries, Kinninmont (2010) proclaims that these countries are taking various measures to ensure long-term sustainable growth. Such measures include:

- proposing energy efficiency measures and techniques
- capitalising on renewable energy and clean fuel supplies
- increasing water efficiency by using water efficient fixtures
- financing new water desalination plants and increasing capacity
- buying or leasing agricultural land abroad.

The GCC region is considered one of the world's most arid regions and water consumption in the region is at its highest level in years. Predictions are that consumption levels will continue to rise (Fatha, Sadikb & Mezhera, 2013). To provide fresh water for the GCC population, desalination plants were deemed the answer. The GCC has the world's largest desalinated water producing regions. Almost 40 per cent of desalinated water is produced in the GCC region (Fatha et al., 2013). Figure 2.3 illustrates the percentage of water desalination of GCC countries compared to the rest of the world where it shows that Saudi Arabia produces 17 per cent of produced water desalination compared to the rest of the world.

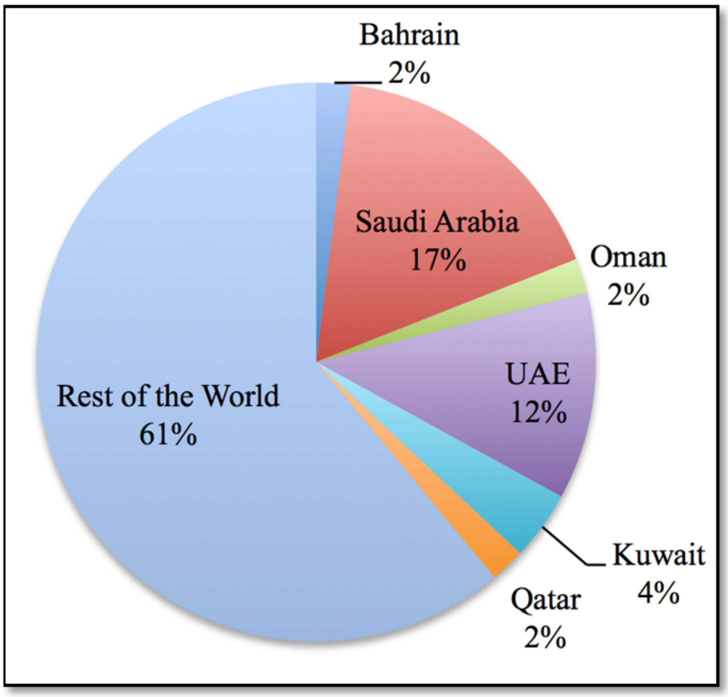

Figure 2.4. Percentage of water desalination of GCC countries compared to the rest of the world (Fatha et al., 2013).

Saudi Arabia is the highest producer of desalinated water in the GCC region. It has 128 desalination plants that produced 12.5 million m^3 of desalinated water by the end of 2011. The UAE has the second highest number of desalination plants, with 98 plants that produced 9.5 million m^3 of desalinated water by the end of 2011. Kuwait, Oman, Qatar and Bahrain have the fewest desalination plants, with 24, 19, 13 and 12 plants respectively, which produced 1.9, 1.7, 1.6 and 1.4 million m^3 of desalinated water by the end of 2011, respectively (Fatha et al., 2013). Figure 2.5 shows the location of the desalination plants in the GCC region, where the majority is constructed around the Arabian Gulf.

Figure 2.5 Location of the desalination plants in Saudi Arabia, adopted from (Fatha et al., 2013, p. 156, Google Earth V7.1.2.2041, 2014).

An indication, according to Kinninmont (2010), that rising water demand will be enormous, comes from the water-intensive lifestyle of the middle class of the GCC, such as private swimming pools, private gardens and golf courses. Without a doubt, some offensive sustainable measurements need to be taken in GCC countries in order to avoid overconsumption, which will put the future generations, if not the present, in jeopardy. Further, Kinninmont (2010) states that desalination costs are paid by the governments and consumers have little incentive to conserve water. Thus, changes to regulations or pricing will have more impact than just public awareness campaigns. Table 2.1 shows the astonishing figure of projected water demand in selected GCC countries between the years 2000 and 2020. Saudi Arabia is the highest water demand country according to these figures.

Table 2.1

Projected Water Demand in Selected GCC Countries, Millions of Imperial Gallons, 2000–2020 (Kinninmont, 2010)

Year	Saudi Arabia	Bahrain	Qatar	Dubai
2000	170,476	27,930	32,303	41,354
2002	188,604	30,387	34,843	49,081
2004	216,205	33,877	34,918	58,357
2006	225,479	36,664	36,116	72,588
2008	240,206	43,181	48,643	91,653
2010	246,065	43,181	56,222	98,178
2012	266,656	43,181	65,111	108,964
2014	290,081	43,181	75,406	123,355
2016	315,564	43,181	84,206	133,361
2018	343,286	43,181	94,116	143,970
2020	373,444	43,181	104,780	155,109

2.3.3 Energy and Water Consumption in Saudi Arabia

Natural resources are depleting all over the world, but in Saudi Arabia, the consumption of energy that is produced from natural non-renewable resources is very high. Providing electricity for housing in Saudi Arabia is one of the biggest challenges facing the country. It is estimated that by 2050, energy demand in the Kingdom will be approximately 120 GW, and to meet this growing demand, 8 million barrels of oil per day will be required (Husain & Khalil, 2013). In addition, according to Fatha et al. (2013), the amassed water production increased from 9.1 Mm^3/day (in 2006) to 23 Mm^3/day (in 2025). However, with this immense increase comes a similar, if not greater, increase in energy consumption. In 2006, the annual total energy consumption was 48,391 GWh and it is estimated to triple by the year 2025 to exceed 119,111 GWh (Fatha et al., 2013). This high demand for fossil fuel will not only put stress on the Kingdom, it will also put stress on the whole world because Saudi Arabia was the world's largest producer and exporter of total petroleum liquids in 2012. In 2009, Saudi Arabia was the world's thirteenth largest consumer of total primary energy, of which about 60 per cent was petroleum-based.

In order to meet domestic power needs and to free up oil and natural gas for export, Saudi Arabia has set a goal of producing almost half of its power from renewable fuels by 2020. Having a sustainable and renewable source of energy is one of the methods to sustain the future for generations to come, in the Kingdom specifically and in the whole world in general. Figure 2.6 shows that more than 50 per cent of fuels used for energy production are constituted from crude oil and heavy fuel oil.

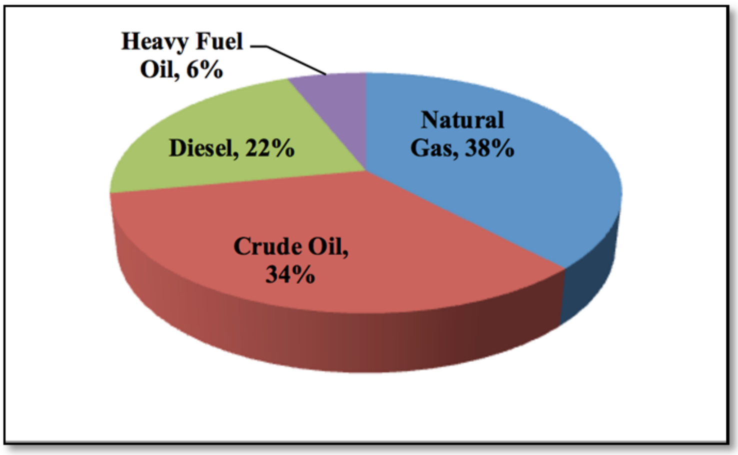

Figure 2.6. Fuel types used in electricity production in Saudi Arabia in 2009 (Husain & Khalil, 2013).

For the past few years, KSA has been the highest per capita oil consumption country in the world. Daily oil barrel consumption equates to 4 million barrels and about 1.5 billion barrels per year, which is the equivalent of 48 barrels a year for every man, woman and child. In comparison, the US consumes nine barrels a year, and Japan consumes five barrels a year for the same individuals (Aluwaisheg, 2013). Little has been done to preserve and conserve the use of Saudi Arabia's main source of income and to make matters worse, there is no alternative transportation system other than the use of private transportation methods. Buildings account for the majority of energy consumption in all countries, however, in Saudi Arabia the amount of energy consumed by buildings is massive. Buildings in Saudi Arabia consume more than 80 per cent of all of the country's produced electricity, where 70 per cent alone is consumed by air conditioning due to the harsh dry climate of the country (Aluwaisheg, 2013).

Overconsumption is a bad habit exercised in Saudi Arabia. According to Aluwaisheg (2013), there are two reasons for the overconsumptive behaviour in Saudi Arabia. The first is that there are no strict laws to bind builders to use a certain type of insulation, which can contribute dramatically in the overall conservation of energy. The second reason is that laws are set to a very low standard when it comes to cooling systems used in buildings, which contributes to high energy consumption levels. It appears from all of the information that Saudi Arabia is heading towards consuming its only major income source before it can solve the problem and consume wisely. However, this can be averted if certain stakeholders collaborate with each other to set new regulations and introduce new energy-efficient methods.

Water scarcity is a reality in countries such as Saudi Arabia, where in 2009, it registered fewer than 90 m^3 of renewable fresh water sources per capita. Figure 2.7 shows the levels of renewable water sources in the GCC nations where the severe water scarcity threshold stands at 500 m^3 per capita per year. In 1980, Saudi Arabia consumed about 10 million m^3 of water and it has increased significantly to reach 17.5 billion m^3 in 2010, which corresponds to a 75 per cent increase (Samad & Bruno, 2013). For this reason, water conservation strategies are necessary in buildings in Saudi Arabia for the continuation of natural fresh water resources in addition to non-natural water resources through water desalination.

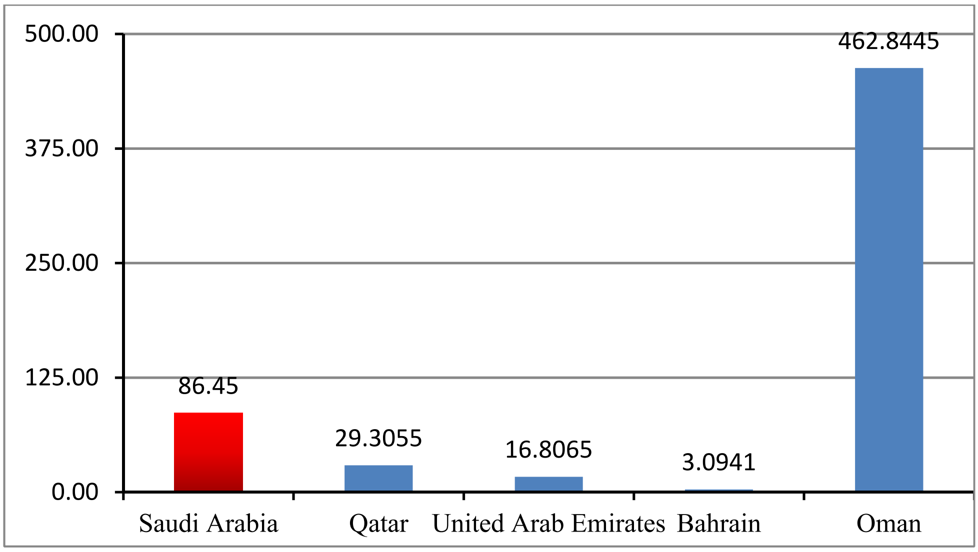

Figure 2.7. Renewable water resources in some of GCC countries in 2011 (The World Bank, 2013).

2.4 CHALLENGES FACING THE HOUSING SECTOR IN SAUDI ARABIA

Although most of the GCC region has witnessed similar economic growth and metamorphosis of housing developments in the past decades, perhaps the greatest challenges are present in the Saudi region due to the greater population expansion and therefore, the greater resulting growth of urbanisation as compared to the surrounding GCC states. The expansions of the population of Saudi Arabia have put extra strain not only on the housing sector, but also on the economy as a whole. This is, of course, reflected in the housing sector as well as other sectors directly related to the population's needs. In addition, the stricter Islamic and traditional practices and values upheld in Saudi Arabia pose more challenges to the possibility of sustainability in housing, as explained in detail in the upcoming sections.

2.4.1 Saudi Arabia’s Demographics and Administrative Regions

Saudi Arabia’s urbanisation level, according to the Central Department of Statistics & Information (2010), is at 82.3 per cent of total population and the rate of urbanisation is 2.38 per cent annual rate of change. The population estimate in 2013 for Saudi Arabia is 29.20 million which includes 32.1 per cent non-nationals (Ministry of Economy and Planning, 2013b). The 2012 census of the five largest urban areas in Saudi Arabia, according to administrative regions, is Riyadh, 7.310 million; Makkah, 7.472 million; Eastern Region, 4.414.3 million; and Al Medina Al Munawarah, 1.911 million (Ministry of Economy and Planning, 2013b). Saudi Arabia is divided into 13 Administrative Regions as illustrated in Figure 2.8. The following table illustrates the population according to each region in Saudi Arabia as reported by the Central Department of Statistics & Information (2010):

Table 2.2

Population According to Administrative Regions (Central Department of Statistics & Information, 2010)

Administrative region name	Capital	Area A (km²)	Population 1992	Population 2010	Population 2013 Forecasted
Al Bāḥah	Al Bāḥah	9921	332,157	411,888	450,700
Al Ḥudūd ash-Shamālīyah [Northern border]	‘Ar’ar	111,797	229,060	320,524	351,000
Al Jawf (incl. Al Qurayyāt)	Sakākah	100,212	268,228	440,009	483,100
Al Madīnah al-Munawwarah [Medina]	Al Madīnah	151,990	1,084,947	1,777,933	1,962,600
Al qaṣīm [Al-qaseem]	Buraydah	58,046	750,979	1,215,858	1,337,600
Ar-riyāḍ [Riyadh]	Ar-riyād	404,240	3,834,986	6,777,146	7,517,000
Ash-sharqīyah [Eastern Region]	Ad-dammām	672,522	2,575,820	4,105,780	4,533,800
Asīr [Aseer]	Abhā	76,693	1,340,168	1,913,392	2,095,900
Ḥā’il	Ḥā’il	103,887	411,284	597,144	654,700
Jīzān	Jīzān	11,671	865,961	1,365,110	1,497,400
Makkah al-Mukarramah [MAKKAH]	Makkah	153,128	4,467,670	6,915,006	7,688,600
Najrān	Najrān	149,511	300,994	505,652	555,100
Tabūk [Tabouk]	Tabūk	146,072	486,134	791,535	866,800
Saudi Arabia	Ar-riyād	2,149,690	16,948,388	27,136,977	29,994,300

Figure 2.8. Saudi Arabian administrative regions (Google Earth V7.1.2.2041, 2014).

2.4.2 Saudi Arabia's Economic Growth

Economic prosperity and urban development in the KSA has rocketed in the past three to four decades. The discovery and commercial exploitation of oil in the 1930s, coupled with the rising market demand in the 1970s in the KSA, has transformed traditional societies into lifestyles similar to those in many developed societies (Mubarak, 1999). This transformation has resulted in an urban sprawl of all major cities in Saudi Arabia.

Saudi Arabia has ample natural resources that include oil, gas, mineral deposits and precious metals. However, most of these natural resources are getting scarcer every day, as discussed in section 2.3. Estimates show that in 2008, the country's recoverable reserves levels had depleted to 267 billion barrels. Saudi Arabia alone reportedly holds more than 21 per cent of the global reservoir. With new technologies emerging and as new extraction techniques arise, it is estimated that the oil reserves of Saudi Arabia will last for 90 years to come, or more (Saudi Arabia Market Information Resource and Directory, 2011).

In addition to the vast oil reserves in Saudi Arabia, especially in the Eastern region, gas is yet another natural resource. According to the Saudi Arabia Market Information Resource and Directory (2011), Saudi Arabia's proven gas reserves stood at 253 trillion cubic feet in 2007, which is an increase of 22 per cent over the estimate for 1997. This increased level of proven gas reserves represents approximately 4 per cent of world reserves. However, when the exploration of oil and gas took place, gas was not utilised at all and was burnt off in flares. After the KSA realised what could potentially be gained from collecting the gas resulting from the oil drilling and refining process, it began to gather it, using it to supply the huge industrial cities of Jubail in the Eastern region and Yanbu in the Western region of Saudi Arabia (Saudi Arabia Market Information Resource and Directory, 2011).

The KSA also has rich mineral deposits. Its history of gold mining dates back some 5000 years, with intermittent periods of vigorous perusal of the precious metal, such as that which occurred during the Islamic Abbasid period, between the 8th and 13th centuries CE. The mine known as the Cradle of Gold (Mahad al-Dhahab), which lies approximately 180 miles north of Jeddah, was found 3000 years ago to be a rich source of gold, silver and copper. Out of the massive 600 sites at which gold had been discovered around the Kingdom, as reported in the Fourth Five-Year Development Plan, 29 have been mined. Petromin re-opened the Mahad al-Dhahab mine with the hopes of it evolving into a high-grade underground gold mine outputting 400 tons of ore daily. This project promoted exploration for other similar locations, resulting in the discovery of other gold deposits, all of which are known to be situated in the Pre-Cambrian rocks of the Arabian Shield, lying in the Western region of Saudi Arabia. Although estimates show that the oil reserves, which are the current base of the economic balance, will last for a mere 90 years from now, it is quite evident that the Kingdom's soil covers yet more various elements of base metal deposits, such as copper, iron lead and more. This is in addition to non-metallic minerals, such as fluorite, potash, high-purity silica sand and more—all of which are yet unexploited, with the possibility of rendering riches, perhaps beyond comprehension (Saudi Arabia Market Information Resource and Directory, 2011).

2.4.3 Rapid Growth of Population and Cities

The increase in economic prosperity witnessed by the KSA over the past three to four decades led to the rapid growth of its major cities. In developing countries like Saudi Arabia, which experience such a rapid rate and ratio of urbanisation, government departments should implement the concept of sustainability and enforce laws and regulations. The quickly diminishing availability of natural resources, due to rapid growth of population, must also be considered. Kennedy and Katoshevski (2007) accentuate not only the pressures experienced by the region from extended population growth, but also warn of the possible change in regional character and identity threat, due to the steadily and dangerous increase of resource consumption. They site that an obvious culprit of this evolution is the defaulting to air conditioning for design solutions, rather than attempting more natural and area-adaptable solutions for building comfort.

Society can benefit greatly from increasing urbanisation, particularly if that urbanisation occurs at a high rate in a short time span. Consequential to the high rate of urbanisation inflicted upon Saudi Arabia within such a short time span are many negative effects. Countries currently undergoing urbanisation developments and expansions, according to Henderson (2002), are facing more challenges than countries that are considered already developed did during their years of development and expansion. He gives the example of Korea, which was at an urbanised level of 40 per cent in 1970 and almost doubled in 1990 to reach 78 per cent. His conclusion is that it took Korea only 20 years and Brazil only 30 years to accomplish the percentage rate of urbanisation that took the US 90 years to establish. Consequently, taking into consideration the estimated growth in Saudi Arabia in the coming years, costs of living will also escalate accordingly. A reasoning provided by Henderson (2002) on this point is that expenses for residents of larger municipalities are higher due to higher costs of living, including but not limited to necessities such as food, housing, public utilities, transportation and so on. He also mentions that these higher expenses do not coincide with higher productivity, as can be found in such metropolises.

Rapid growth in cities around Saudi Arabia has led to several dilemmas that have risen from the late 1970s during the ‘oil-boom phase’ (Garba, 2004). One of the resulting problems of the immense population growth of that period was the increasing demand for services from residents, which exceeded what the Government could manage. The cause of the country’s expedited growth of cities according to Gamboa (2008) was by the use of no-interest loans. Another dilemma is that there was no initiation of defined boundaries for the city, nor laws against those who penetrated the city boundaries. Gamboa (2008) affirms this and argues that the breach of urban development to the city's walls left an infinite amount of space for growth. This might seem an opportunity for developers, but the reality is it created several obstacles for developing and maintaining proper services and infrastructure for residents.

As an example of how the rapid growth took place in Saudi Arabia, the capital city of Saudi Arabia, Riyadh, will be discussed here. Riyadh is one of the fastest growing cities in the Middle East, where the population rate of less than 15,000 at the turn of the 20th century rocketed (as of 2014) to nearly 7.5 million, with the projection of expanding to around 10 million by 2020 (Central Department of Statistics & Information, 2010). The pace of Riyadh's growth is examined by Garba (2004), who states that the city underwent two urban development plans that covered a total area of 1782 kilometres^2 (km). The first urban development plan comprised 1150 km^2, while the second urban development plan covered an area of 682 km^2. Gamboa (2008) agrees with what Garba (2004) states as facts and accentuates that in a little under 100 years, the city of Riyadh grew from a 1 km^2 bounded medina (city) to a 3000 km^2 metropolitan zone due to the Saudi Government's provision of low- to no-interest loans (Gamboa, 2008).

Tremendous challenges of management for the public sector often accompany urban growth, particularly when that growth is unusually rapid. The necessity of insurance of the expansion of services to meet the growing needs of the increasing population, in addition to the need to ensure that growth and development occur in an orderly and sustainable fashion, are the two basic elements from which these challenges emerge (Garba, 2004).

2.4.4 Environmental Challenges (Climate Change and Natural Resource Depletion)

The environment is a sensitive component in Islam (Al Ghamdi, 1995). As a result, the Muslim culture requires housing designs that show concern for the surrounding environment (Syme, Nancarrow & MaCreddin, 2002). The Muslim culture according to Syme et al. (2002) requires every believer to show respect for benefits acquired from animals, land and forests because they come from Allah's blessings. In other words, a believer should not abuse natural resources through the direct or implied impacts of their actions (Swanson, 1996). Islam, according to Swanson (1996), is completely adamant that people should not utilise natural resources to the resource's extent alone. In fact, utilising a natural resource to the resource's extent alone is tantamount to committing sin. Thus, it is important to protect and keep the environment for only the benefits that Allah exclusively intended.

Within a period of 40 to 200 years, non-renewable natural resources, such as oil, natural gas and coal, will be consumed if not managed in a sustainable way to last for future generations (Ting et al., 2011). Availability of natural resources in any country can mean economic prosperity and a better lifestyle for residents. Oil, for example, has made the KSA a rich country and it has dramatically transformed from a tribal desert country into one of the world's largest oil producing countries. However, oil is the only major export of the country and dependency on it alone can mean catastrophe when the oil wells dry out. To meet the growing demand of energy production in Saudi Arabia, 8 million barrels of oil per day will be required. This high demand for fossil fuel will not only put stress on the KSA, but also on the whole world because Saudi Arabia was the world's largest producer and exporter of total petroleum liquids in 2012. Saudi Arabia was the world's 13th largest consumer of total primary energy in 2009, of which about 60 per cent was petroleum-based (US Energy Information Administration, 2013).

Saudi Arabia is one of the top environmentally challenged countries around the world. According to Al Fadl (2010), Saudi Arabia's ecological footprint is roughly twice the world average, standing at 4.5 hectares of ecological footprint per person. Not only that, but among the environmentally challenged countries of the world, the country is ranked in the top 20. The climate in Saudi Arabia is generally harsh, dry desert conditions with extreme temperature differences ranging from -11^{o}C to 51.1^{o}C (Piccolo, 2010). Figure 2.9 shows that Saudi Arabia is categorised as an arid climate country with low percentages of precipitation in winters and hot arid temperatures in summers as illustrated by Kottek, Grieser, Beck, Rudolf and Rubel (2006).

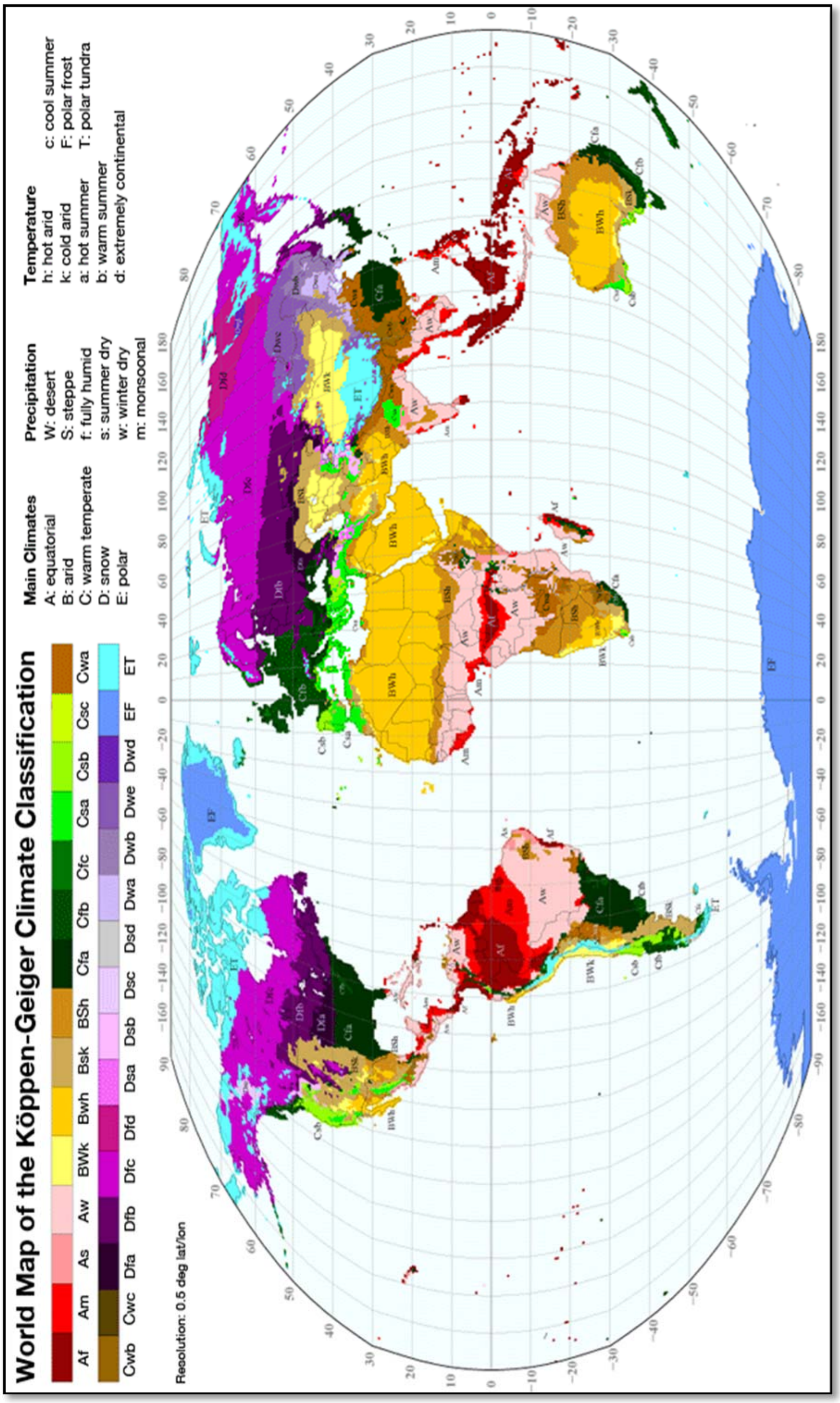

Figure 2.9. World map of the Koppen-Geiger climate classification (Kottek et al., 2006, p. 261).

Table 2.3 illustrates the average temperatures for the 13 administrative regions of Saudi Arabia throughout the year. The coldest average temperature was recorded in Assir region and the hottest average temperature was recorded in Makkah region. Saudi Arabia and many Arabian countries, such as Egypt, share the same climate conditions and culture. The climate of Upper Egypt is hot and arid, with a large difference between day and night temperatures (Fathy, 1973).

Table 2.3

Saudi Arabia's Administrative Regions Monthly Average Temperatures in ^{o}C (Weatherbase, 2014)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yearly average
Al Bahah	12.7	14.3	17.3	18.8	22.3	24.9	25.6	25.4	23.6	19.3	16	13.4	19.5
Ar'ar (Northern border)	8	11	15	21	26	31	33	32	30	23	16	11	21.4
Al Jawf	9	11	16	21	26	30	31	31	30	23	16	11	21.3
Al Madina al Munawarah (Medina)	17	20	23	27	32	35	35	35	35	29	23	19	27.5
Al qaṣīm [Al-qaseem]	12	15	19	24	30	32	33	33	31	26	19	15	24.1
Riyadh (Central region)	14	16	20	25	30	33	34	34	31	26	20	15	24.8
Dammam (Eastern region)	15.6	16.9	20.8	25.5	30.8	34	35.5	35.1	32.6	28.4	23	17.6	26.3
Assir	13	14	16	18	21	23	23	22	21	18	15	13	18.1
Ḥā'il	10	12	16	22	27	30	31	31	29	23	17	12	21.7
Gizan (Jīzān)	25	26	27	30	32	33	33	32	32	31	28	26	29.6
Makkah al-Mukarramah	23	24	27	31	34	35	35	35	35	32	28	25	30.3
Najrān	15.3	17.8	21	22.8	25.9	17.4	28.5	28.2	25.6	20.8	18	15.7	21.4
Tabūk [Tabouk]	10	13	17	22	26	29	30	30	28	23	17	12	21.4
Monthly average	14.2	16.2	19.6	23.7	27.9	29.8	31.4	31.1	29.5	24.8	19.7	15.8	

Figure 2.10 illustrates the ecological footprint of Saudi Arabia alongside several other Arab and non-Arab countries.

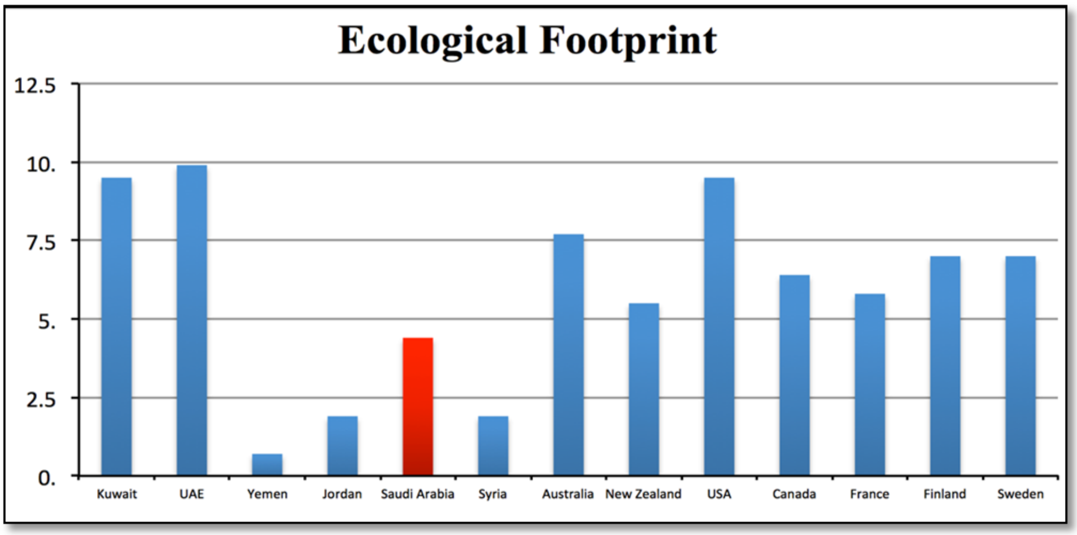

Figure 2.10. Ecological footprint of different countries (Wackernagel, Moran, Goldfinger, Monfreda & Drexle, 2004).

Another challenge facing Saudi Arabia and other Arab countries is the scarcity of water, as discussed in section 2.3. Many of the Arab countries, to respond to the growing demands of the populations, have resorted to relying heavily on non-renewable groundwater supplies to boost their scarce water supply (Swain, 1998). In addition, due to the staggering increase in demand for water in GCC countries, and extremely limited conventional water resources, such as fresh surface water and renewable groundwater, alternative sources such as wastewater reclamation and desalination have been adopted since the 1960s (Stensgaard, 2008). High consumption rate and overexploitation of vast amounts of fossil water reserves over the past decades, as argued by Spiess (2008), threatens the remaining reserves with saltwater intrusion in GCC countries. This is quite alarming because four of the six GCC countries are ranked among the 10 most water-scarce countries in the world.

Further, Spiess (2008) adds that severe groundwater depletion in both quantity and quality is mainly caused by continuous water extraction, production, as well as utilisation, particularly in the municipal, industrial and highly subsidised agricultural sectors. Additionally, this depletion has also caused loss of habitat and biological diversity, soil and water salinisation, declining productivity, thermal and chemical pollution and permanent ecosystem degradation.

In 1980, Saudi Arabia consumed about 10 million m^3 of water and it has increased significantly to reach 17.5 billion m^3 in 2010, which corresponds to a 75 per cent increase (Samad & Bruno, 2013). For this reason, water conservation strategies are necessary in buildings in Saudi Arabia for the continuation of natural fresh water resources in addition to non-natural water resources through desalination of seawater. Saudi Arabia began operations at the world's largest solar-powered water desalination plant, according to the Saudi Gazette (2013), in the city of Khafji in 2012. The plant's capacity is about 30,000 m^3/day, which will help reduce some of the strain on the country's conventional desalination plants. This new plant will help the water-scarce country meet the high demand from the population and at the same time be powered by natural resources of energy.

2.4.5 Economic Challenges

Oil wealth has made Saudi Arabia an economically prosperous country. The country has the largest oil reserves in the world, which has greatly affected its economic growth since the 1930s. Large-scale production did not begin until after World War II, and it intensified in the 1960s and 1970s, transforming the country into one of the fastest developing countries in the MENA region. In terms of exports and revenue, 90 per cent of the country's exports are from oil, and it accounts for nearly 75 per cent of Government's revenues (US Department of State, 2011).

Before the 'oil-boom' days, the Saudi house was designed and built according to the wealth of the family living in it. Different climate conditions dictated how the windows should face or whether there would be a courtyard in the centre of the house or not. However, after the 'oil-boom', villas started to appear and the trend of the nowadays-typical Saudi house appeared. Tents turned into villas and mud-built houses that shared walls and rooftops with adjacent neighbours turned into vast blocks of land with resort-like houses that were inspired by Western designs. The booming economy of Saudi Arabia had its fair share in the transformation of the traditional Saudi house; traditions transformed according to the economic shifts of the country (Gamboa, 2008; Garba, 2004; Mahmud, 2009; Sidawi, 2008; Susilawati & Al Surf, 2011).

However, with the transformation from tents to modern day villas comes an adverse side effect: the segregation between low- and middle-income families and the high-class high-income families. The effect of segregating people according to their economic state is very common all around the world. In Saudi Arabia, it is not much different from the rest of the world, whereby it is not uncommon to find wealthy communities living in one location, while the lower income families live in another part of the city. However, is it a healthy act to differentiate between people according to how much they have in their bank accounts? Watson (2005) argues that segregating a neighbourhood according to income will result in lack of exposure of the low to middle-income neighbourhood members to the role models of the high-income class, which results in disequilibrium in the social network, which contributes to urban unemployment and social problems. Moreover, social attachment between groups is less likely to be established because children who grow up in segregated neighbourhoods will not prefer to relocate to other neighbourhoods if they were given the choice.

The vast oil reserves of Saudi Arabia, as well as multibillion-dollar budget surpluses and impressive economic cities, are all factors contributing to the concealment of the truth of the real estate sector of the KSA. Luxurious waterfront villas and pretentious gated communities catering to a small percentage of the Saudi population, which is now hovering at around 22 million, can hardly conceal the truth of the situation. Sadly, in reality, a growing number of people across the country suffer from lack of adequate housing, and this problem is progressively (Roberts, 2010). The housing problem of Saudi Arabia, according to Karam (2010), is based on the evolution of the country's demography. Recent census reports show that the country's population increased nearly 20 per cent to a ceiling of 27.14 million between 2004 and 2010, largely due to the sharp increase in the foreign work force. Independent economist Saud Jleadan reports that with an annual increase of 150,000 units, the country has a current deficit of 2 million housing units. Experts of the housing industry such as REFCO (Saudi-based mortgage lender 'Real Estate Financing Co.') and Clayton Holdings (US consultancy) have estimated that Saudi homeowners are only 30 per cent of the population—a decrease of more than half of the percentage of the Saudi population, who were homeowners only 20 years ago (Karam, 2010).

For the world's largest oil exporter, these are striking numbers signifying an alarmingly uneven distribution of wealth and benefits. The strong demographics of the growing national population of Saudi Arabia indicate a strong and sustainable demand for infrastructure. With 66 per cent of the population under the age of 25, it is clear that continued demand for growth of a solid social and economic infrastructure is a sure factor of future development (Business Monitor International, 2011). With the problem of an unbalanced economical state comes the trend of owning versus renting. The ratio of renting compared to owning property in Saudi Arabia is very high, with about 70 per cent of residents living in rented housing in Saudi Arabia (Karam, 2010). What makes matters worse is that there is no set of regulations or standards that compels property owners to ensure the safety, security, health and wellbeing of the tenants (Colvin, 2006).

Propelling a new wave of assistance in terms of direct financial aid in addition to various economic benefits to reinforce Saudi Arabia's housing industry and boost education, King Abdullah bin Abdul-Aziz has initiated a series of direct royal decrees for immediate implementation with an estimated cost of SR135bn ($36bn). Dubbed as a 'Keynesian approach' to the current turmoil and political up-rise of the region, the 19 new measures introduced by King Abdullah on 23 February 2011 encompass a variety of social benefits, such as a pioneering venture of unemployment benefits promising to provide one year's worth of wages to jobless Saudis who are actively seeking work. The measures also include write-offs for debts and other similar social benefits for the needy. Chief economist John Sfakianakis of the Banque Saudi Fransi says taking into consideration the higher oil prices and net foreign assets of SR1650bn at the end of 2010, Saudi Arabia can comfortably afford to finance such social policies. The policies will assist the indigenous population with the rising challenge of unemployment and the associated problems, such as the imbalance of the housing market, due in part to the rising cost of property (Timewell, 2011).

The near-to-non-existence of mortgage financing is the main factor for the current disequilibrium in the Saudi residential property market. Although there is a substantial pent-up demand for middle or low-end residential real estate, the actual demand—in other words potential investors able to purchase this type of housing without assistance of a mortgage—is quite limited. Therefore, Saudi property developers are reluctant to even build such projects, hence a further increase in the housing deficit as compared to the needs of the community. Limited financing is available, culminating in bank mortgage lending reaching only 3 per cent of gross domestic product (GDP) in Saudi Arabia, as compared with 6 per cent in Kuwait and 7 per cent in the UAE, and over 50 per cent in many of the developed countries of the world. Soft loans provided by the Real Estate Development Fund (REDF) have proven inadequate because of the high demand for housing and the length of the approval process. The mortgages built upon Islamic terms, which are provided by commercial banks, are confined to those who can meet the requirement of the large down payments (Savard, Reeve, Gilmour & Ahmed, 2010). Saudis are governed by Islamic rules and being financed according to the rulings of Islamic guidance is no exception. 'Islamic finance is depicted as (and, in essence, ought to be) an ethical and equitable mode of financing that derives its principles from the sharia (Islamic law)' (Balala, 2010).

Another economical dilemma in Saudi Arabia is the reliance on fossil fuels to generate electricity; residents use almost all appliances at least once throughout any given day and keep air conditioners operating all day as well. This seems to mimic lifestyles and behaviours of Western societies that are mostly luxurious and far from being sustainable where overconsumption is a trend. For example, the Saudi house is designed to be vast and contains multiple rooms that require continuous conditioning to reach a comfortable temperature. This practiced behaviour by all levels of the population spreads all over the country, which creates the need to design and apply energy-efficient techniques and the reduction of water consumption in Saudi buildings through the application of sustainable architectural principles (Karam, 2010).

It is extremely rare in the oil-rich Saudi Arabia, according to Taleb and Sharples (2011), to use sustainable energy technologies, such as solar photovoltaic panels (PV). Further, in spite of the abundant availability of renewable energy sources, producing electricity in Saudi Arabia is wholly reliant on the unsustainable practice of burning fossil fuels. These unsustainable practices of overconsumption and energy generation cause irreversible environmental impacts on air, climate, water and land. Figure 2.11 illustrates the consumption of electricity in some of the Arab countries where the usage peeks during the months of June, July and August when air conditioners are normally on all day. Figure 2.12 shows the increasing electricity consumption in Saudi Arabia from the year 2000 to 2009.

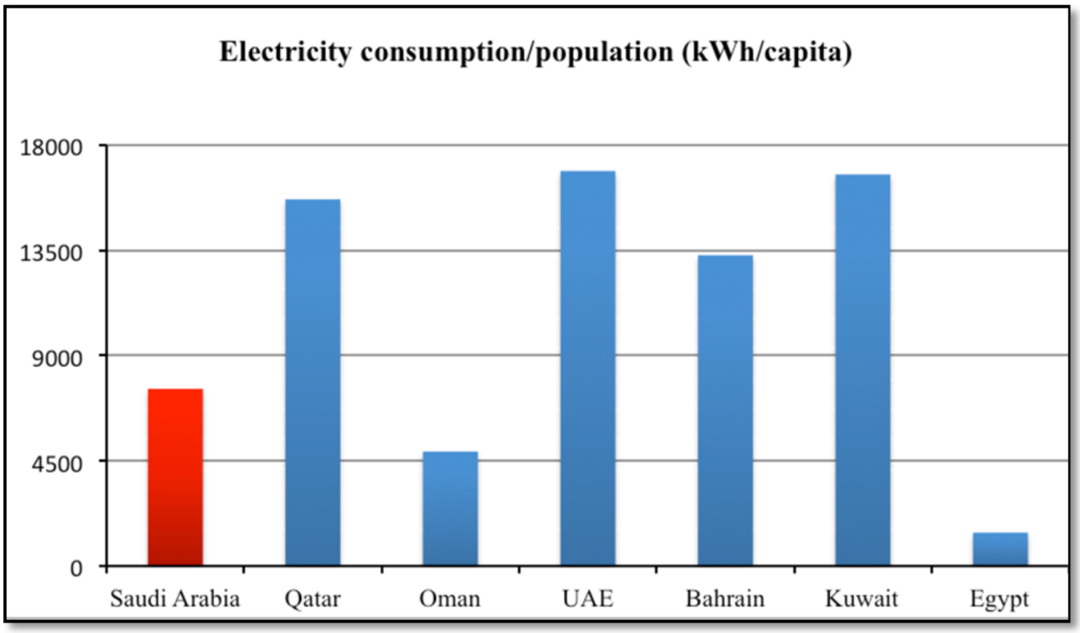

Figure 2.11. Electricity consumption of Arab countries (International Energy Agency, 2010).

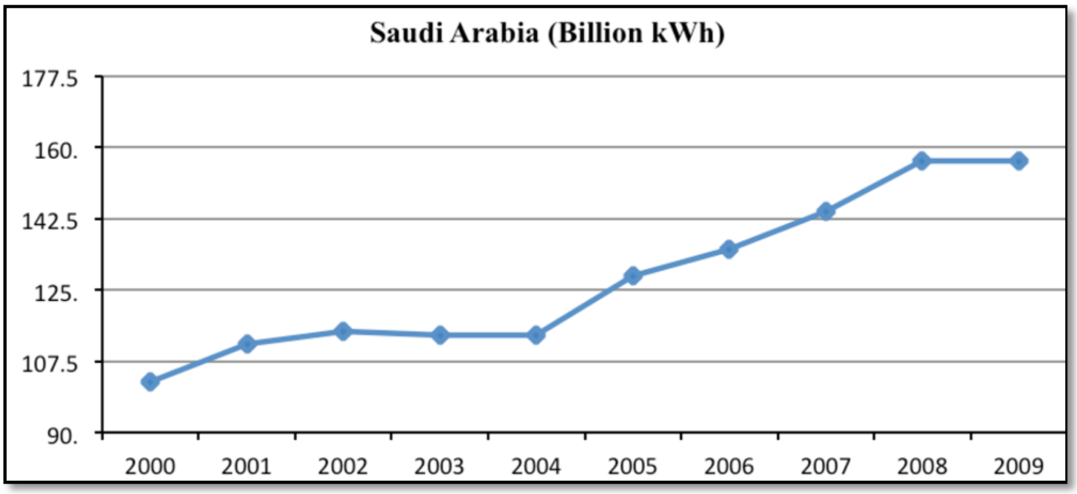

Figure 2.12. Increasing electricity consumption in Saudi Arabia from the year 2000 to 2009 (CIA World Fact Book, 2011).

Affording to buy a house in the Saudi real estate market can seem like a dream for the majority of the Saudi population and it is another economic challenge facing the application of housing sustainability to housing in Saudi Arabia. The mean annual gross income per capita in 2007 for men, according to Opoku and Abdul-

Muhmin (2010), was around SR26,876 (US$7166) and for women this figure is much lower, at around SR7491 (US$1997). With these levels of income, no Saudi family can buy a house straight off the real estate market. Traditional Saudi housing used to accommodate three to four generations under one roof. However, with the economic shift in the country, priorities have changed and young couples choose to live separately nowadays rather than with the extended family members. This change in housing choice has further put strain on the current deficit in the real estate market.

King Abdullah bin Abdul-Aziz announced a housing scheme in March 2011 to build 500,000 homes over several years. At a time when social dissatisfaction was prompting uprisings in other Arab countries, his plan was part of a series of official steps to improve social welfare (Dokoupil & Rashad, 2013). However, since that decree in 2011, not much has happened and the construction of the housing projects has been very slow. This is mainly due to the lack of land given for the construction of these housing projects. However, in April 2013, King Abdullah bin Abdul-Aziz issued another decree removing an obstacle to a US$67 billion program to ease the country's housing shortage. The decree provided a boost for the housing construction industry in Saudi Arabia, as it brings with it the promise of opening up thousands of acres of state-owned land for these construction projects to take place (Dokoupil & Rashad, 2013). The first step for the Government after the decree is to fill the gap between the supply and demand of housing the Kingdom. The Saudi Government must address this gap because the young aged demographic of the Kingdom for many years to come will lay the groundwork for sustainable housing (Assaf, Bubshaitr & Al Muwasheer, 2010).

2.4.6 Socio-Cultural Challenges

For a long time, the delivery of housing products to Saudi residents has utilised a traditional approach because demand for housing in Saudi Arabia emerged due to variations in levels of income and population growth (Mahmud, 2009). It regards cost reduction as the main factor and disregards the other factors (Salama, 2006). The designers, according to Sidawi (2008), have neglected the Saudi's cultural norms, lifestyles and traditions. Incorporating these dimensions, as argued by Sidawi (2008), into housing design decreases the overall cost of the product, or in other words, its lifetime cost (maintenance and running cost, renovation and alteration expenses). This would affect property life and the user's life positively. Therefore, housing designers bear the responsibility of providing tailored and sustainable housing that meets user needs, while the users bear the responsibility of using the houses in a sustainable manner (Gamboa, 2008).

Culture is defined by the Merriam-Webster dictionary as:

> The customary beliefs, social forms, and material traits of a racial, religious, or social group; also: the characteristic features of everyday existence (as diversions or a way of life) shared by people in a place or time. (2011)

The Saudi culture is defined by the teachings of Islam and is governed by the Qur'an and the Hadith, a collection of traditions containing sayings of the prophet Muhammad (Peace Be Upon Him). Islam, according to Champan, Petersen and Smith-Moran (2000), is a comprehensive way of life where all human activities, such as education, business, social interaction or science, are driven and governed by God-consciousness. Hence, the population, the environment and the consumption of anything within it is considered from a view that it is of God's creation, no matter whether it be from a religious or a scientific angle.

The culture of Saudi residents is a family-oriented. All family members are close and the elderly are respected and considered the leaders and wise members of the family (North & Tripp, 2009). Traditionally several generations, three to four, may live under one roof, where the elderly are looked after by the younger generations and given great respect. With this multigenerational household in mind, it is evident that the Saudi house would be larger in scale as opposed to those where a single family live in a two bedroom unit or similar.

The Saudi culture can be described as the most conservative culture in the world (Burkhart & Goodman, 1998). Islam is the religion that is followed 100 per cent in Saudi Arabia. Islam also governs the Saudi society in all aspects of their lives, from eating and sleeping to praying. The Qur'an and the Hadith of Prophet Mohammed (PBUH) are followed and applied in everyday activities. An Islamic society revolves around the five prayers in each day and so each individual's day is organised around those five prayers. Islam is reflected in a design of a Saudi or Muslim house because of the segregation between male and female members of the family. In any given situation, Muslim women must wear modest clothes that cover her whole body and also wear a Hijab that covers her head. A Muslim women should not reveal herself to any man, except for her father, brother, uncle, husband, son, nephews (of blood relation) and grandfather. This requirement has greatly influenced the design of the Muslim house, thereby necessitating the need for the implementation of separating sections: one for males and the other for females.

Segregation between male and female sections in a Saudi house is typical and mandatory to follow the Islamic ways of living.

The cultural and religious background of a Saudi determines how far they would live from a mosque, also affecting the design of a Saudi house in many ways. Since it is mandatory for a Muslim to pray five times a day, closeness to a mosque is a necessity in the Saudi culture. Traditional neighbourhoods were all centred around a central large Masjid (mosque), which was generally surrounded by the village or town. The Masjid grew into more than simply a centre for worship. It became surrounded by markets and medical centres, in addition to facilitating the gathering of religious groupings, and addressing any issues concerning the town. The Masjid was the place to discuss important issues or access the townsfolks' needs and necessities. Figure 2.13 shows a satellite image taken of the city of Riyadh, where it shows how many Masjids are in a small area of the city, illustrating how living near a Masjid is significant to the Saudi population.

Figure 2.13. The importance of a *Masjid* in a neighbourhood in Saudi Arabia (Riyadh)—four *Masjids* in less than a 1 km radius (Google Maps, 2014b).

Traditionally, one large *Masjid* would suffice for the whole town, which had several advantages. One main advantage was that the whole town could see each other and ask about each other's wellbeing. Another advantage was that it became a place to make announcements to the local community, as they all prayed in the same *Masjid*. Nowadays, one can find several *Masjids* in 1 km^2, as seen in Figure 2.13. This has more disadvantages than people would realise. One of the many disadvantages of having so many *Masjids* in one neighbourhood is that people do not interact with one another as they used to in previous times. Another disadvantage is that there is no regulation against how many *Masjids* can be built in one neighbourhood, which affects the interconnectivity of the residents of any neighbourhood.

A typical Saudi home is designed to be as far away from the public's eyes as possible. Privacy, according to Abu-Ghazzeh (1996), is paramount in the design of any Saudi house and all stakeholders involved in development projects in Saudi Arabia, such as urban designers, architects, landscape architects and social scientists, should respect this crucial aspect of design. Additionally, according to Mahmud (2009), privacy is paramount in the design of housing for occupants ascribing to the Muslim culture. In this culture, privacy, especially for women, is extremely imperative. Privacy is crucial in the design of a Saudi house, and the concept of privacy is observed in three different areas as stated by Daneshpour (2011): privacy between dwellings and neighbours as well as the street, privacy between sexes and privacy between individual family members of a dwelling.

Segregation is one of the most important Muslim standards that a house design should incorporate. Muslim culture advocates for segregation, especially women from public life in the streets. This fact is true in Saudi Arabia where the segregation between male and female sections in a house is typical and mandatory to follow the Islamic ways of living. Evidence from the Holy Qur'an demonstrates that there should be separate parts in one's home that separate men from women. Verse No. 53 of Surat al-Ahzab, or the Confederates (Interpretation of the meaning): 'for anything ye want, ask them from before a screen: that makes for greater purity for your hearts and for theirs'. In explaining this verse, Ibn Kathir (a well-known scholar of interpreting the meaning of verses of the Holy Qur'an) said:

> Meaning, as I forbade you to enter their rooms, I forbid you to look at them at all. If one wants to take something from a woman, one should do so without looking at her. If one wants to ask a woman for something, the same has to be done from behind a screen. (Al Mubarkpuri, 2003)

As it is unmistakable that segregation between males and females is obligatory, designers should respect this fact and integrate isolated sections for both sexes so that comfort can be attained for all dwellers of any Saudi house.

Breaching privacy is the main issue that residents in Riyadh deal with today. This is the result of lack of proper building codes preventing the construction of high-rise buildings in close proximity to low-rise private homes. This has caused the residents of homes to suffer a breach of their privacy, something that is accentuated even more in the MENA region because of the prohibitions on this imposed by the religion and culture. Unplanned distribution of the residential areas has been the instigating factor resulting in a potentially dangerous mixture of foreign single labour forces that would rather live in densely-populated apartment complexes, living in or nearby previously designated detached single family dwelling areas. This has led to many serious security issues across the city of Riyadh in addition to the rest of the Kingdom (Gamboa, 2008).

2.4.7 Application Challenges

The application of sustainability to a building is a complex process; the sheer newness of this concept to the public has been perhaps the greatest deterrent, magnified by the perception of it being expensive. However, among housing industry professionals in Saudi Arabia, awareness of this innovative concept is on the rise. A critical element in the sustainability program, as argued by Eden (2000), is the interaction between local governments, planners and citizenship involvement in the planning and implementation stages. He goes on to remind us of the necessity to explore how the citizenship views sustainability and how they are willing to participate in the implementation in order to coordinate cooperation between the sectors. With the large estimated population in Saudi Arabia, it is no easy task to apply a new concept to a country that has developed from living in tents in the 1930s to having a sustainable scheme applied to the housing sector and convince them that this the right way.

Sustainable housing implementation requires strong support from the public, government and the housing industry. However, the public does not understand the language and the meaning of sustainable housing, as discussed in section 2.2. The involvement of the stakeholders is crucial in the development of any sustainable development and especially in a developing country. The application of appropriate standards and procedures, as argued by Miranda and Marulanda (2001), such as those of sustainable standards, cannot be initiated if the governments are not the ones to do so. This initiation by governments will pressure the construction industry to adopt and introduce the required sustainable adjustments, which will change the private sectors', as well as other professionals', ways of thinking. Ultimately, this will change the thinking of the public in general. After the way of thinking towards the environment has been changed, then, and only then, the benefits and advantages of a sustainable built environment can be realised and reaped. However, the problem is not whether governments can initiate the change or not. The problem is that the governments of developing countries still believe that sustainable construction and sustainable development are not yet a priority. This puts a greater burden on professionals in certain fields to change the ideologies of governments.

Governments are stakeholders in the construction industry, and when considering the project stakeholders, Reffat (2004) lists the various stakeholders to be involved in the successful application of sustainable development and their roles, which include:

- Politicians: Sustainability issues should actively appear on the agenda of political leadership.
- Manufacturers: Environmental responsiveness should constitute a criterion in materials or product specifications.
- Local authorities: Sustainability should constitute a criterion or drive requirements for plan approvals, land use or land sub-division.
- Built environment professionals: Sustainability considerations should make it to the brief, design criteria or specifications. Related training institutions have a key role to play for training in these issues. (Reffat, 2004, p. 3)

Lack of public awareness is one of the challenging factors threatening the successful application of sustainability in the KSA. A paper was published by Susilawati and Al Surf (2011), which clearly demonstrated the level of awareness of the Saudi public. The paper's main methodology for collecting data was through a web-based survey that was distributed to participants through the Saudi Council of Engineers. The main aim of using the Saudi Council of Engineers was because this council holds the database of names for engineers involved in the Saudi construction industry. The participants represent a small sample of the Saudi population and their input was considered indicative of the general public's knowledge on sustainability in general and sustainable housing in specific. The paper showed that over 52.2 per cent of the participants are not aware of sustainability and have not heard the term 'sustainable housing' before participating in the web-based survey. However, only 3 per cent of participants said that sustainable development would not save money. What is more, more than 70 per cent of participants agreed that sustainable housing would save energy bills (electricity and water) once they understood sustainability and its benefits.

Once the participants who participated in the web-based survey were introduced to the definition of sustainability and its benefits, they were asked to list any housing projects they might know of which could be classified as being sustainable. Only 21 per cent of the participants thought that sustainable housing projects existed in Saudi Arabia. The rest of the participants did not know or did not think that there were any sustainable housing projects in Saudi Arabia. However, when the ideas and benefits of sustainability were well known to the participants, they were asked if they would be willing to retrofit their current houses to be sustainable. Over 71 per cent of the participants were willing to retrofit their houses to be sustainable if they were given the chance or when possible.

The participants were then asked to rate their response ranging from the lowest (not important) to the highest (very important) to the level of acceptance and type of housing ranging from building traditional houses, building sustainable houses or retrofitting existing houses to be sustainable. The answers were somewhat spread throughout the range, but more than 80 per cent agreed that it is important to build sustainable housing projects and more than 63 per cent agreed that it is important to retrofit existing houses to become sustainable. Further, the participants detailed and elaborated on how they would retrofit or build sustainable housing projects by introducing and using natural daylight and by using solar-powered water heating tanks. However, when they were asked if they would utilise rainwater collection tanks, they were evenly divided, because the half who disagreed to incorporate these rainwater collecting tanks thought it would be useless to use them due to lack of rain in the desert climate of the country.

The participants in the public awareness paper were given the chance to comment and express their feelings on how to incorporate sustainability in housing projects in Saudi Arabia. Many of the participants agreed that there needs to be a dramatic behavioural change in the general public and this can be seen in some of the participants' comments, such as:

> P-2: It is a good idea, yet it has to be accompanied with change in people's thinking.
>
> P-11: I think sustainability has a great benefit on the environment and humans. However, people's awareness about this term should be increased to gain maximum advantages.
>
> P-8: I wish houses could be built this way in Saudi Arabia, and I also wish it was mandatory and enforced and an essential part of the forthcoming SBC.

> However, before that, awareness is necessary to convince owners to go that way. All existing public buildings should be refurbished and made greener and cleaner.

Other participants expressed their opinions in relation to the Government's role to mandate sustainability measures on all construction in Saudi Arabia. Such comments include the following:

> P-9: I think that the idea of sustainable buildings should not remain an idea, on the contrary, it must be included in the building code and applied gradually so as not to become a choice but become a necessity for the design and construction. I think that the main role here is located on the engineering bodies and governmental institutions to try to enforce these systems on each of the works in construction.

2.5 SUMMARY

It is clear that a housing crisis exists in Saudi Arabia, where affordable housing is not equivalent to the percentage of population needing such housing. In addition, it is clear that Saudi Arabia, as well as being afflicted naturally by a harsh arid climate, is also afflicted by high consumption of non-renewable natural resources. This combination, if not remedied by alternative choices in the near future, will prove to be disastrous for future generations.

Some of the other complications and challenges facing the implementation of sustainable housing in Saudi Arabia is the sheer cost of its initiation, compounded by the environmental as well as socio-cultural aspects, in addition of course to the essential challenges of the application. In retrospect, concerning these aspects and more, it has become clear that it is necessary for governmental intervention in the means of introducing and enforcing building codes and regulations, as well as implementing internationally accepted and accredited sustainability rating systems such as LEED.

Chapter 3: Socio-Cultural Design Aspects and the Role of the Saudi Government

3.1 INTRODUCTION

Sustainability is a concept not only concerned with the environmental impact of structures, but also the needs of low- and middle-income families in relation to the rising costs of investment in housing units. When applied to the housing sector in Saudi Arabia, the harsh climate is a strong influence. However, the highly conservative Islamic culture also poses further constrictions that need to be addressed.

Saudi Arabia’s housing sector has been invaded with modern Western-style structures that have proven to be unsustainable as far as energy and environmental concerns are considered. In addition, they have not, for the most part, incorporated the conservative cultural needs of the Islamic society. A probable remedy for this would be to drift back towards the architectural styles of the vernacular structures, which incorporated easily accessible local products for construction. In addition, they implemented styles more accommodating to the climate as well as the conservative Islamic culture, both within the individual units as well as the community as a whole, providing the necessary privacy within the abode as well as between the structures themselves.

Modern Saudi architecture can still achieve sustainability by utilising vernacular elements, but a set of regulations and codes must accompany such developments. This is where the role of the local Saudi Government comes into play, as well as the connection between the construction sector and the governing bodies, which need to create and dictate a firm building code. In addition, to the local Saudi governing agencies' construction and housing sector policies, a broader commitment to widely used international building codes and sustainability rating systems, such as LEED, is an important consideration for improving the sustainability of Saudi Arabia's housing and construction sector.

3.2 VERNACULAR ARCHITECTURE VERSUS MODERN ARCHITECTURE

Saudi Arabia's traditional architecture employed the historic element of the varied styles according to the different regions of the country. This entailed the implementation and usage of local (regional) elements into the building structures, such as mud, stone and wood. Architectural designs differed between regions. The designs varied according to the climate or cultural traditions of the society of that particular region. Shihabi (2004, p. 59) states: 'the wide-ranging variance in environmental conditions and social norms has resulted in distinct architectural expressions of which there are living examples of a diversified architectural heritage'.

Traditional vernacular Saudi dwellings can easily be identified according to the design and building materials used in the dwelling. However, the modern trend towards the typical Western-style villa has lost this element of regional signatures to the structures. It is no longer easy to identify which region of the country a dwelling is located in simply by viewing its outer structure. This is because modern structures are all built from the same elements in general, and follow the same general structural design. This transition from identifiable and unique structures that represent the local community to non-identifiable structures that mimic the Western-style villas is the main discussion of this section.

3.2.1 Vernacular Architecture

The Fiqh, which is the Islamic code of jurisprudence that is based on the Holy Qur'an and the Sunnah (the sayings and deeds of Prophet Mohammed PBUH), was the code that builders in the past obeyed and followed. Such codes included neighbours' rights, rights of way, rights of privacy (for example, segregation of males and females) (Abu-Ghazzeh, 1997). Vernacular architecture in Saudi Arabia utilised local building materials, which varied from one part of the country to another, and used passive and low-energy strategies that minimised the need for air conditioning and lighting (Taleb & Sharples, 2011). In fact, it was this vernacular architecture of the past that enabled Saudis to historically cope with the harsh climatic conditions. In many parts of the country, the courtyard was the focal point of the house, while other parts of the country emphasised the windows and covered them with Mashrabiyas.

Considering the vast geographical expanse of the KSA, many different terrains affect the design of a house. Due to the vast differences in climates and natural resources available in each region of Saudi Arabia, there are differences between buildings in each region that the locals erected, providing necessary protection from the elements of each of those regions. For example, houses in the South-western region were mainly made from stone (see Figure 3.1), while houses in the central and Eastern regions were built from mud reinforced with wooden beams (see Figure 3.2).

In Figure 3.1, the tower that is shown is from the Assir region, in the South-western part of Saudi Arabia, which is a mountainous area with abundant supplies of rocks and stones. The buildings in that area of Saudi used to have the lower floor for animals, which had no openings, guests would have the floor above that, and the remaining floors were reserved for the inner family members. In summer, the guests would go to the rooftop to take advantage of the cool summer breeze. Little or no courtyards are present in this area of the KSA, which is suitable for that region due to the cold climate conditions. Small windows would be opened, situated high above the ground floor and are used for ventilation, with no viewing permitted due to privacy reasons. In addition, the windows were designed to be small for security purposes to protect its inhabitants from outsiders if there was a battle or any conflict.

Figure 3.1. Traditional Assiry stone tower (Assir region).

The case is different for houses in the central region, Figure 3.2, because the climate is different. The climatic conditions of the central region of Saudi Arabia are that of a harsh desert, with temperatures ranging from extreme heat to extreme cold conditions. Temperatures can reach to up to 50^{o}C in summer or as low as -11^{o}C in winter.

Figure 3.2. Traditional neighbourhood in Addir'iyah (Riyadh region) . (Ar-Riyadh Development Authority, 2014)

Other regions of Saudi Arabia used straw and palm tree leaves as the main building material for the roof and mud walls, such as the huts that were built in the Jizan region as illustrated in Figure 3.3. This was mainly due to the high humidity levels in that region; air flow need to flow through the building material to ventilate the interior, which led to a comfortable indoor environment.

Figure 3.3. Traditional Jizan huts, adopted from (Lafforgue, 2010).

In order to cope with the extreme weather conditions in this area, the people living there built their houses from what was available to them, which was sand. They made sun-dried clay bricks and used mud as mortar mixed with straws and reinforced the structure with wooden beams. The design of the houses included an inner courtyard that was the main gathering area for the family in the summer and minimal openings were visible from the outside walls. All surrounding rooms of a courtyard had openings looking on to the courtyard. This style of architecture proved beneficial because of the ventilation it provided for the surrounding rooms. Figure 3.4 illustrates the air circulation provided by a courtyard in a traditional Saudi house.

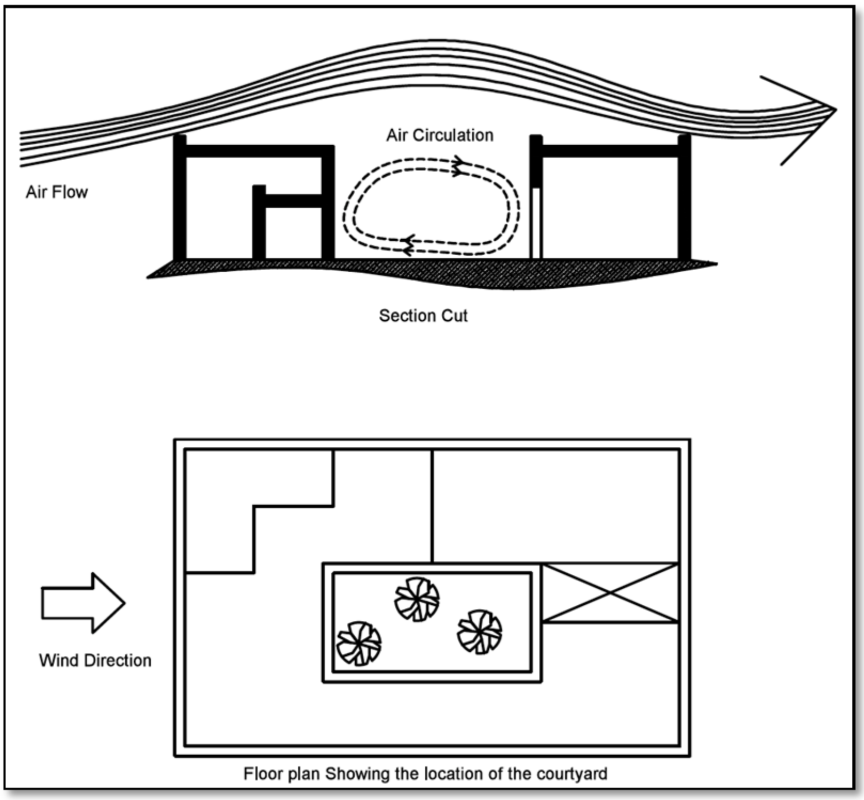

Figure 3.4. Airflow in a traditional courtyard, adopted from (Mabrouk, 2006).

The design aspect of privacy necessitates proper use of space and orientation of the courtyard. The courtyard concept was common among Muslims mainly because it satisfied their social and religious needs—especially privacy. Additionally, the courtyard's arrangements provided their environmental needs. Accordingly, it is vital that sustaining the environment penetrates through the design of the Saudi house, which is evident in the design of the courtyard. The courtyard should face the inside rather than the main street. In vernacular housing designs, features such as high walls on roofs, door and entry area arrangement and windows create the impression of privacy. Most of the spaces should face the internal courtyard to avoid situations where the openings in adjacent buildings face one another. Figure 3.5 illustrates an old neighbourhood in the city of Riyadh and it is obvious that every house had a courtyard.

Figure 3.5. A layout of traditional Saudi houses showing courtyards in every house, Addir'iyah (Riyadh region). (Ar-Riyadh Development Authority, 2014).

In the hot dry arid zones, which form most parts of Saudi Arabia, thermal comfort is a necessity, (Al Ghamdi, 1995; Swanson, 1996). As a result, sustainable housing design should cater for this environmental need. 'The courtyard provides the required optimum environmental conditions and at the same time provides the required privacy' (Jameel & Hafith, 2012, p. 324). The design of the courtyard should facilitate free air circulation through convection and should consider the changing seasons and incorporate it into the design. In hot dry weather, the courtyard air, which should be hot due to the sun's heat at daytime, rises, to pave the way for cool and dense night air flowing downwards into the court. The amassed cool air within the courtyard penetrates and cools the surrounding rooms. The four walls in the courtyard provide shade during the day. According to Al Ghamdi (1995), this ensures that air inside the courtyard absorbs heat slowly and maintains its coolness until the late hours of the day. To keep housing costs affordable for low- and middle-income earners, the designer should choose the size and number of courtyards fitting for the available space, and use only local building materials.

The houses in the neighbourhood would be designed and built close to each other, and in most cases, linked. One whole neighbourhood was an extended family, where all houses were linked for several reasons, one of which was so female members of the neighbourhood would move between houses without having to cover up from outsiders' peering eyes. Another reason is for security purposes, because in those days, many conflicts necessitated that houses shielded each other from outsiders penetrating the neighbourhood.

Additional traditional architectural feature that enhanced the indoor environment was the use of wind towers or wind catchers (Malqaf). This method was mainly used in the Eastern region of Saudi Arabia, where the weather was humid year round. Figures 3.6 and 3.7 illustrate the typical wind towers from the Eastern Province and how air circulated inside the house creating a pleasant environment for inhabitants.

Figure 3.6. Typical Saudi house in the Eastern region with wind towers.

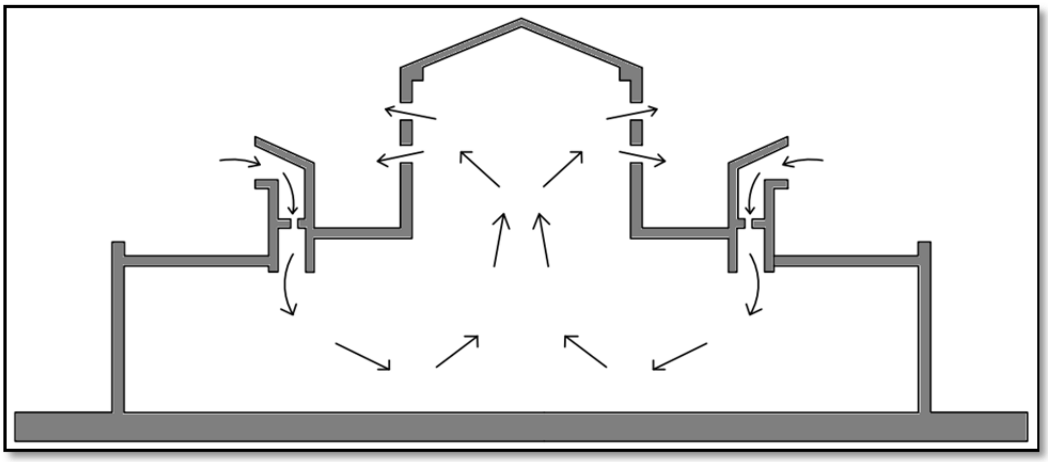

Figure 3.7. Air circulation provided by the wind towers in a traditional house (Malqaf), adopted from (Al Shaali, 2002; Jameel & Hafith, 2012).

Eben Saleh (1998) describes the traditional neighbourhood in Saudi Arabia, pointing out the positions of the neighbourhoods' crucial geographical points, such as water access, trade routes, and the proximities of the sacred mosques or administrative centres. Water abundance would be the mark of where a neighbourhood would settle and the first building constructed would usually be the *Masjid* (mosque). The *Masjid* would be designed with large open spaces for local gatherings, decision-making meetings and local markets. Houses would then surround the *Masjid*, characterised by winding, narrow alleyways.

3.2.2 Modern Saudi Architecture

The Arab world, according to Ali (1989), experienced a modernisation period after it became independent from colonising countries. As a result of this freedom status, it rushed towards adopting and importing Western methods and implementing them into planning and architecture. The Saudi population experienced these great changes within a period of two generations, which is significantly short. Lifestyles have been influenced by both internal and external factors. In addition, problematic and irreversible changes in traditional construction methods and materials have emerged. These particular changes in construction methods and building materials created a gap in the building culture and the social culture, which could not be reinterpreted to meet the social demand of the Saudi population (Shihabi, 2004).

The Saudi neighbourhood changed from an organic layout to a gridiron plan, which is typical to those in Western societies. This gridiron neighbourhood design neglected the need to interconnect members of the neighbourhood, as was the case in vernacular architecture neighbourhoods. Even though each neighbourhood might have some amenities in walking distance, it is not safe for residents to walk to those amenities because the current neighbourhood design in most of the Saudi cities does not provide safe pedestrian access to those amenities. This necessitated the continuous use of cars for short distances, which has environmental effects and congests road for reasons that could have been avoided if proper designs were implemented (Eben Saleh, 2002).

Privacy was also neglected and close proximity between houses meant that high fences needed to be erected to cover the windows and outer corridors surrounding the building. This modification, that some residents tend to do, pollutes the visual neighbourhood elevation and places greater economic burdens on residents who do not wish for their family members to be seen by passing pedestrians. This contradicts the vernacular design of windows and adjacent buildings, where the height of the windows was carefully studied and positioned to provide privacy for residents from the peering eyes of passing pedestrians (Eben Saleh, 2002).

This Westernised neighbourhood design also neglected the need to comply with each region's climate conditions to provide residents of each individual region with thermal comfort needs through passive designs that were used in vernacular architecture buildings. Such instances where this has been neglected are evident in the orientation of houses in a neighbourhood block. The same house design is used as a stamp in one block and the orientation of the site and where the windows should be positioned is not considered. This results, for example, in having heating ventilation and air conditioning (HVAC) systems in houses with windows facing west and south work consume more energy than houses of the same neighbourhood with windows facing the optimal north or east (Attia, 2013; Eben Saleh, 2002; Gamboa, 2008; Garba, 2004).

Figure 3.9 illustrates a typical modern Saudi neighbourhood development in the city of Jeddah, located in the Western Province of Saudi Arabia. It is visible how the 'stamp' style of houses is used in one block of the neighbourhood. Figure 3.10 illustrates a typical Saudi neighbourhood from an aerial perspective, where it is clear how the gridiron or axial design of Western societies has been adopted in the design of modern Saudi neighbourhoods.

Figure 3.9. Typical modern Saudi neighbourhood in Jeddah.

Figure 3.10. Typical Saudi neighbourhood from an aerial perspective, Jeddah.

In contrast to the environmental concerns tackled by traditional builders in the Saudi construction industry, modern Saudi houses lack many environmental protections. Neglecting the surrounding environment and the culture of the society is a norm in modern Saudi architecture. Additionally, no effort is being put into the design of a modern Saudi house, as is explained by Attia (2013) when he argued that the designs are merely copied from one region to the other regardless of the local variations. Further, 'Site selection is usually based on political decision without concern for the site environmental sensitivity, existing infrastructure or transportation' (Attia, 2013, p. 225).

3.3 DESIGN ASPECTS FOR THE CONSERVATIVE ISLAMIC CULTURE OF SAUDI ARABIA

The population of Saudi Arabia is unique to the rest of the world, in that its traditional culture is affected directly by Islamic teachings. Therefore, the housing needs of the Saudi population are unique, and must be taken into consideration in order for sustainability to be achieved in the region. The relativity of the house to the Masjid and how the surrounding neighbourhood is erected plays an important role in the sustainability of the community. In addition, privacy is an important factor for such design, which necessitates attention to entrances, windows and segregation as well as privacy as it relates to the neighbouring structures. Finally, usage of natural elements such as airflow and natural lighting need to be integrated into the design as well (Abu-Ghazzeh, 1997; Al Hemaidi, 2001; Daneshpour, 2011; Eben Saleh, 2002; El-Shorbagy, 2010; Hamdy, 2000; Mubarak, 1999).

3.3.1 Relativity to a *Masjid* (Mosque)

The importance of a Masjid to the conservative Saudi Muslim culture has already been touched on. It is imperative that urban and city planners, together with architects, merge their knowledge and efforts with the city councils to regulate how many *Masjids* can be built in one neighbourhood and how far they should be from one another. One of the many ideas that the Saudi Ministry of Municipal and Rural Affairs should consider, is to localise one main *Masjid* for the one neighbourhood where the five prayers can be performed, as well as the Friday prayer and other religious occasions such as the *Eid*. This *Masjid* should be located in the neighbourhood centre, which provides all the neighbourhood's needs, ranging from government offices to commercial outlets. Therefore, the neighbourhood would be intact and the residents in each neighbourhood would not have to travel far distances from one side of the city to the other to fulfil his or her needs (Al Surf, Susilawati & Trigunarsyah, 2012).

There are many advantages that can be achieved through Saudi sustainable neighbourhood design. One main advantage is that it will immensely reduce the need for using cars and other means of travel because the entire neighbourhood's needs are within walking distances. Another advantage is that the whole neighbourhood would interact with each other and cater for each other's needs. All the members of that neighbourhood would be generally informed of any missing need or requirement of their neighbourhood (Al Fouzan, 2012).

In utilising this concept of localisation of each neighbourhood's requirements and needs, architects and city planners have to consider how to design the *Masjid* and its location and the surrounding amenities so that it is within reasonable walking distance from the farthest house in the neighbourhood. Some design features have to be considered in order for this concept to triumph, such as the use of shading devices to cover the pedestrian pathways to create a pleasant comfortable environment for the walking neighbourhood. This concept would encourage the residents of the neighbourhood to go out more often and utilise these walking areas for exercise or to mingle with other members of their neighbourhood. However, it is imperative that all safety requirements must be taken into consideration and implemented into the design to ensure safety and encourage residents to enjoy recreation activities. These safety requirements must include certain measurements, such as the safe design of pedestrian footpaths that ensure the safety of the local neighbourhood to walk to local services or to the *Masjid*. Additionally, street crossings must ensure the safety of the pedestrians by installing signage systems and traffic lights that give way for pedestrians to cross streets safely (Al Fouzan, 2012).

3.3.2 Privacy

A typical Saudi home (see figures 3.11 and 3.12) is designed to be as far away from the public's eyes as possible. An ideal home in the eyes of a typical Saudi is a high-walled self-contained villa far away from the gazing eyes of the neighbours or pedestrians. Within the high-walled area, several buildings may exist that are linked to each other and house extended families (North & Tripp, 2009). This is why in any Saudi street, the typical skyline would be of high fences surrounding homes, such that the design of the house might not even be noticeable, except from within the boundaries of that fence. Hence, much effort is put into the elevation of a house, but opens an opportunity for courtyard designs that could be of great value to making the house a more sustainable one.

Figure 3.11. Typical Saudi villas in Jeddah.

Traditional Saudi buildings incorporated and respected the concept of privacy. In modern Saudi houses, however, this has been neglected and windows need to have curtains drawn all day or covered up by sheets of corrugated aluminium, as depicted in Figure 3.12.

Figure 3.12. Typical Saudi house with the fence and roof walled by corrugated aluminium, from Abha in the Assir region.

In traditional Saudi houses, however, small windows would be opened, situated high above the ground floor and used for ventilation, with no viewing permitted due to privacy reasons. In addition, the windows were designed to be small for security purposes to protect inhabitants from outsiders if there was a battle, as depicted in Figure 3.13.

Figure 3.13. Traditional Saudi house from Assir region showing the high-level position of windows above street level.

Privacy is also achievable from the unique design of the entrance (Al Ghamdi, 1995). In houses with two entrances, the main entrance should open towards the direction of a courtyard. The other entrance should be the doorway, a key external feature that should be at the ground floor position or level. The entrance preserves the family's privacy by opening into a blank wall. This orientation obstructs views from outside into the inside. Figure 3.14 illustrates clearly how privacy was achieved in vernacular houses by having an L-shaped entrance that leads directly into a courtyard.

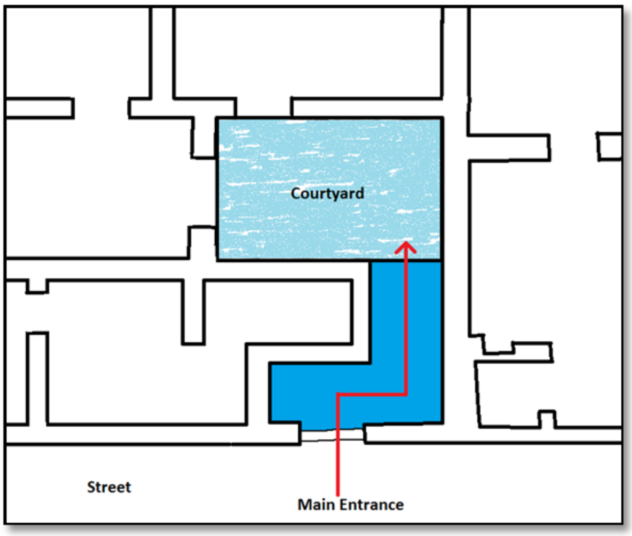

Figure 3.14. How to design the main entrance in vernacular houses, adopted from (El-Shorbagy, 2010).

Window design is crucial to achieving privacy in vernacular architecture of Saudi Arabia. Windows were positioned high above the peering eyes of the passing pedestrians. Another house might have the floor level below the street level to provide privacy because the eye sight angle of pedestrians will not see the family's female members. Figure 3.15 illustrates a diagram of the positions of the windows in traditional Saudi houses.

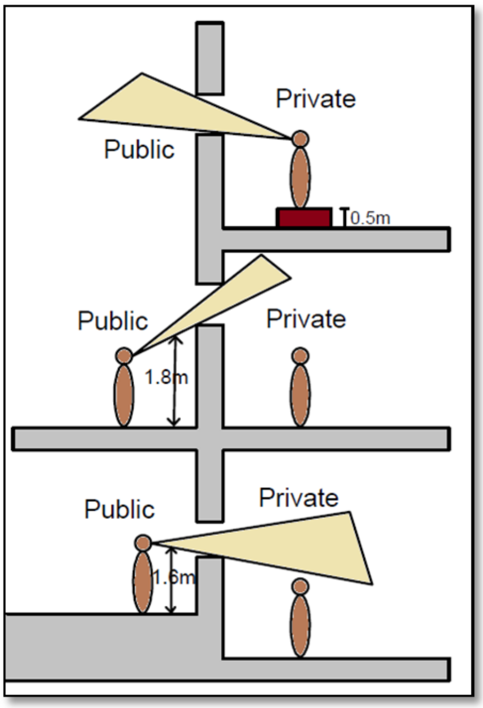

Figure 3.15. Window design in vernacular architecture of Saudi Arabia, adopted from (Weber & Yannas, 2014).

Other architectural elements that can contribute immensely to the environmental comfort of Saudi house inhabitants, is the design and installation of windows that have Mashrabiya installed on them. The Mashrabiya (see figures 3.16, 3.17 and 3.18) is a traditional wooden mesh that is installed over a window, which lets in light and air but gives the inhabitants a sense of privacy as well.

Figure 3.16. A typical Mashrabiya in the city of Jeddah.

Figure 3.17. A modern building in Jeddah that utilises the Mashrabiya.

Figure 3.18. A more detailed Mashrabiya on a building in Jeddah.

However, according to Samuels (2010), these Mashrabiyas are no longer in use because of economic constraints and the time span to construct one. Considering the fact that both the time and cost involved in the construction of a Mashrabiya in the traditional way have proven to be high, the alternative of using light weight material that resembles the traditional material that was used in previous times might prove to be cost-effective and worthwhile (Samuels, 2010). Therefore, revolutionising the concept of the Mashrabiya and considering standardising its fabrication requirements, could result in more cost-effective house construction. This would require collaboration among the stakeholders of housing development.

One of the methods of incorporating Islamic culture in architectural designs and the vernacular architecture of Saudi Arabia is by utilising light, as it plays a decorative role by creating patterns or modifying various elements. In the Muslim culture, light is a symbol of divine unity. The Quran itself describes God as the light of the Earth and the heavens (Kamaruzaman & Siti, 2011; The Holy Qur'an). Just as light gets nothing from a shadow, the reality of things extends to the sharing of the light of existence. Viewing light directly creates a blinding effect. However, people use harmony in colours to define nature, which, in itself carries every visual phenomenon. Therefore, Muslim artists aspire to transform their designs into vibrations of light.

3.3.3 Segregation

The house design should separate private and public life, maintaining independence as discussed in Chapter 2. Al Hazmi and Nyland (2010) point out the importance of segregation in Saudi Arabia by stating that gender segregation is fundamental in people's activities: social, educational and political. To incorporate this belief in housing design, the housing designer should divide the house into three distinct areas: private areas for the inner family members, such as the father and the mother, semi-private areas for the whole family, such as the living room and public guest zones for men or female guests.

The traditional Islamic-Arab house layout, according to El-Shorbagy (2010), segregated the house into public, semi-public and private areas. Women mainly use the private areas of the house, while men use the other parts. He also adds that the design of the house is an inward looking design where the outside walls are generally bland, which discourages strangers from looking inside. Al Hazmi and Nyland (2010) agree with El-Shorbagy (2010) and state that the Saudi men divide their social life into two separate worlds: the public world and the private world. The public world is where the men conduct all work-related activities while the private world is the haven in which they retreat from all the day's hassle and strive to keep safe and secure.

3.4 BUILDING CODES AND REGULATIONS

Modern Saudi architecture lacks the sustainability that was achieved by traditional or vernacular Saudi architecture. However, sustainability can still be achieved by utilising vernacular elements and concepts such as passive cooling and ventilation through courtyards. To achieve this, a set of regulations and codes must accompany developments. Not only is it important that the Saudi Government instil effective building codes, it is also imperative that the Saudi Building Code (SBC) be reviewed in timely fashion for development and enforcement. In addition, internationally effective and environmentally conscious building codes, such as the LEED sustainability rating system discussed in detail in section 3.4.5, should be introduced and implemented into the housing sector. It has been put to use in various government and non-government structures in Saudi Arabia, and has proven effective for sustainability in more ways than one. However, using international sustainability rating systems, such as the LEED, may not prove suitable for the KSA, due to inapplicability of some of the rating system's points to the uniqueness of KSA's socio-cultural, economic and environmental aspects.

3.4.1 Purpose of Building Codes

A building code is a set of rules that specifies the minimum acceptable level of safety for buildings and other constructed objects. The history of building codes dates back more than 4000 years ago where the Babylonian Code of Hammurabi issued the death penalty to a builder of a collapsed house if that house collapsed on its owner due to not following the building code (Ching & Winkel, 2012). From its inception, the sole purpose of building codes is to protect the inhabitants from building-related risks such as fire, structural collapse and other risks. Additionally, environmental performance assessment of built projects across a range of key criteria is the reason behind developing green rating systems.

Environmental disasters such as hurricanes, earthquakes, floods and fires test any building's structural integrity to the limit. Building codes help improve and maintain a building's structural stability that will withstand hazards, such as fire and structural collapse. Additionally, building codes can serve to reduce the impact of environmental disasters, such hurricane Katrina in 2005 and the 2010 earthquakes in Christchurch. According to Rotimia, Masuriera, and Wilkinson (2006), safe development of infrastructure, land usage and improvements in general are some results of legislation applied to and enforced upon the construction industry. However, it is apparent there is little provision in some areas of legislation that applies to or facilitates projects involving reconstruction.

Post-disaster restorations can utilise the shortcomings of a building's pre-disaster structural conditions to improve it for any future disasters that may occur in the area. In fact, this must be the case in areas where environmental disasters occur frequently. Amaratunga and Haigh (2011, p. 7) state: 'Post disaster period provides a window of opportunity to address many of the vulnerabilities usually encountered in a community's built environment'. Post-disaster restoration creates a fresh start to rebuild non-vulnerable communities where disaster risks can be addressed effectively. Further, disasters typically generate new knowledge that can give immense insight and experience to various stakeholders brought together by the disaster, who share the awareness of the risks. Previous development policies and strategies are uncovered and can be managed to minimise the possibility of such risks ever occurring again (Amaratunga & Haigh, 2011). Lee (2013) states that rebuilding a community after a disaster is vital, and from the ashes of any environment rebuilt after disaster, the chances of a better and more resilient community against future disasters, with newer spirits and an even stronger sense of community than before, becomes more likely.

3.4.2 Role of the Saudi Government

As with any other region of the world, the role of the municipal as well as national government bodies is pivotal in the application and progress of sustainable housing construction in the KSA. It is necessary therefore, to learn who the key stakeholders are in Saudi Arabia, and what their contributions are or have been towards enforcing the application of sustainability to housing construction in the region. Of the various obstacles preventing or delaying the application of sustainable housing construction in Saudi Arabia, perhaps the increase in prices of land procurement is the greatest. It is possible that a scheme of a private-public partnership can be created for applying sustainability to housing construction in Saudi Arabia.

One problem is dominant in the Saudi real estate market: the absence of property tax. Consequently, large vacant land lots are found in inner city districts, which stand in the way of the Kingdom's urban development. The price of land in the current Saudi property market has increased by 50 per cent in the past few years. Further, 50 per cent of the cost of building a home in Saudi Arabia is paying for the land, compared to about a third in Europe (Fattah, 2013). Applying new laws that limit the number of vacant land one can own in a period might be a solution aside from applying taxes. This can help reduce the price of land and can help speed the development of inner city areas that have stood vacant for long periods.

The high price of land in Saudi Arabia, according to Ferris-Lay (2011), has prevented the progress of affordable housing developments because developers are reluctant to pay ridiculously high prices. Even if developers commit and decide to build their development in the outskirts of the city, they would have to account for infrastructure costs as well, such as roads, power, sewage, schools and hospitals. This has discouraged developers from building affordable houses in Saudi Arabia, crippling the development of the country. This has further discouraged the development of sustainable housing projects at an affordable price for low- and middle-income families.

To illustrate how much is needed for an average Saudi resident to be able to afford a decent house, Hasan (2011) states that a Saudi national needs to meet the 45 per cent loan to income criteria to be approved for a loan. This means that the minimum required monthly salary should be SAR 9209. This salary range can buy a moderate house worth SAR 550,500, but requires a 20-year mortgage loan with 90 per cent financing at an 8 per cent interest rate.

Stakeholder involvement, argued by Mathur, Price, and Austin (2008), is a necessity for the successful achievement of the ambitious goal of sustainability. This involvement requires, among other efforts, firm and decisive decision-making processes and new kinds of governance. Stakeholder involvement in urban development projects in any country needs to be collaborative in order to achieve common goals that are based upon pooling resources, agreed priorities and maximising comparative advantages (Mandeli, 2008). Collaboration between all stakeholders is essential in the success of any industry to flourish and prosper. However, progress is likely to remain limited according to CA News Network (2013a). New sustainable laws have to be mandated and enforced on developers. New initiatives are on the rise in the country, such as King Abdullah’s Green Building initiative and other initiatives by the Saudi Energy Efficiency Centre (SEEC). However, as long as developers are unclear on the financial and environmental benefits of adopting these initiatives, they will not be applied to buildings. The following is a list of all stakeholders in the Saudi housing industry that should be involved in the decision-making and application of sustainable construction methods in Saudi Arabia:

- Ministry of Housing and Public Works (Public Stakeholder)
- REDF
- national banks
- the private sector either with or without loans from REDF
- institutions that provide housing for their employees (such as the Saudi Arabian Oil Company, ARAMCO and Saudi Basic Industries Corporation, SABIC)
- joint-stock companies with funds from both the Government and individuals (Assaf et al., 2010).

The role of the Saudi Government can have a direct influence on the construction industry and that can be in the implementation and the mandating of sustainable construction methods through the SBC.

3.4.3 The Saudi Building Code

Inception of the SBC started in June 2000, when a Royal Decree formulated the Saudi Building Code National Committee (SBCNC), the members of which are Saudi nationals from government, academic, and private sectors. The SBC was established on several international building codes from the US, Canada, Australia, and Europe in addition to the Arab building code. The national building code of Saudi Arabia was first approved by the Council of Ministers in September 2001, and the first version of the code was available for the public in 2007. As with any building codes, the SBC is a set of rules and regulations that specify the minimum standard of constructing a building. This code insures the safety and wellbeing of the public. The International Code Council had a substantial influence on the formulation of the SBC, but is not liable for any amendments done by the SBCNC to the building code.

In 2003, the SBCNC involved several key stakeholders from the Government and private sector, universities and research centres, and other specialists to develop the SBC, which adheres to the unique social and cultural aspects of the country, the distinctive environmental conditions, and types of soils and properties of materials available in the country (SBCNC, 2007). The SBCNC held several specialised meetings, seminars, workshops and symposiums to develop the code and to give stakeholders a chance to deliberate and discuss related issues.

The Ministry of Municipal and Rural Affairs (MOMRA) is the main government body under which the SBCNC operates. Some of the MOMRA's tasks and responsibilities include:

- classification of contractors
- management of the construction and building sector database
- management of the Mina and the Holy Sites Development Project
- the building and construction of laboratories
- managing and implementing the building code
- applying the real estate registration system in coordination with the Ministry of Justice
- issuing municipal licenses for commercial, industrial, artisanal and vocational activities (Ministry of Economy and Planning, 2013a).

Since March 2007, the concept of sustainable buildings in Saudi Arabia was not a reality and immature practicing was done at that time and prior to it. However, after the formulation of the Saudi Green Building Council (SGBC) in March 2007, the SBC was one of the main objectives of this council. Currently, the SGBC is promoting the practice of green building through the following:

- raising public awareness through campaigns
- providing training and education for professionals
- helping the construction industry to adapt green building requirements
- inspiring building materials manufactures and suppliers to create and source environmentally friendly products and materials
- encourage green labelling
- adapt, develop and operate a local green building rating system that considers the local social, economic, and environmental needs with the help of the international experience (CA News Network, 2013b).

3.4.4 Environmentally Conscious Building Codes

In the past two to three decades, the focus of governments, such as the US, Canada, UK, and Australia, was to make the building codes environmentally friendly. Those governments have developed building codes that promote sustainability such as LEED, BREEAM, Green Globes, and Green Star. Additionally, some of the Arab countries have developed their own sustainability building rating systems, such as Estidama in the UAE, and the Qatar Sustainability Assessment System (QSAS) in Qatar. This global movement towards a more conscious construction environment is still voluntary and the rating systems such as LEED are still a third party in the construction industry. Developers may be reluctant to use green building techniques because of the dominant perception of higher building costs.

This way of thinking is normal but to determine if the true value of applying green building techniques a worthwhile investment, one needs to analyse the design, construction, operation and maintenance cost of a building (Partee, 2009). Energy cost is one of the tangible measurements that can to prove that sustainable buildings do cost less to operate and maintain. Commercial buildings that have applied sustainable methods and have been granted a LEED certification have proven to have lower energy costs by up to 6 per cent than normal commercial buildings (Partee, 2009).

While green building codes are still voluntary, green building activists and sustainable real estate stakeholders are pushing governments to mandate these green building codes. To illustrate the importance of mandating green building codes, the US Green Building Council states that even when buildings today have applied sustainable methods and are considered the greenest building there is, there is still a net negative impact on the environment. The choice is not between applying building codes and using sustainability rating systems. Both are needed (US Green Building Council, 2014a). Figure 3.19 is adapted from the US Green Building Council's LEED and Green Building Codes Policy Brief, where it illustrates the huge negative environmental impact of buildings in the present day. It also shows how far we still have to go for our buildings to achieve zero environmental impact.

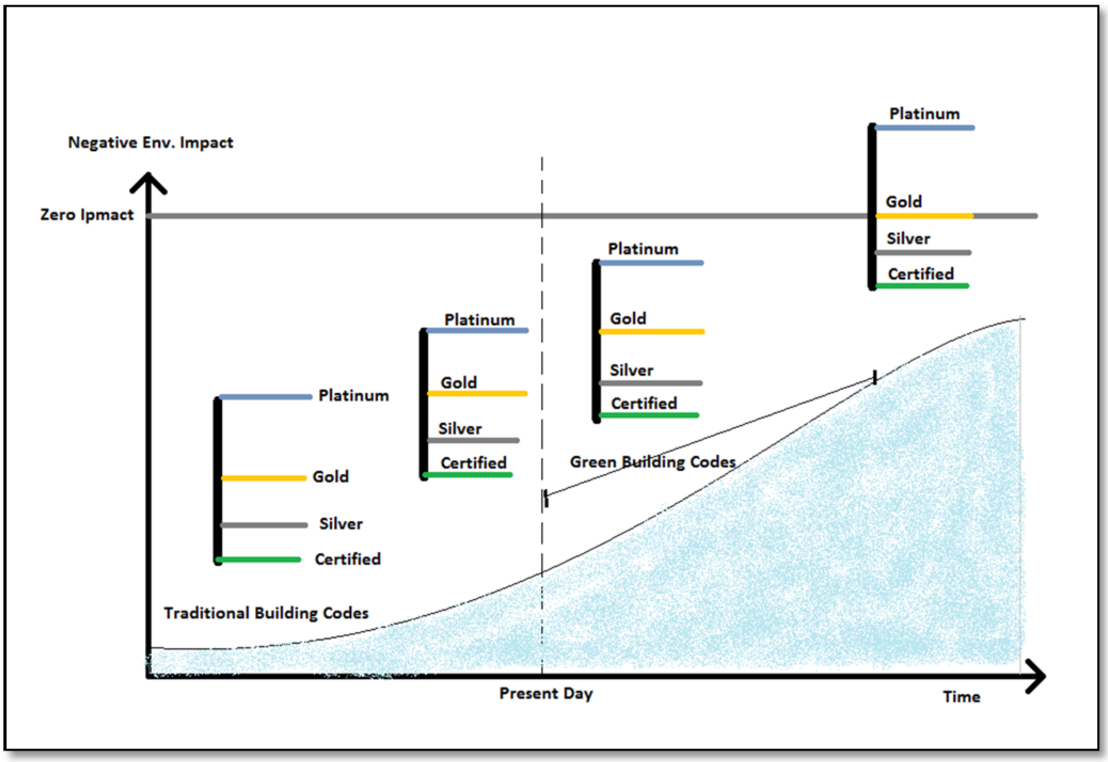

Figure 3.19. LEED, codes and green building codes, adopted from (US Green Building Council, 2014a).

3.4.5 LEED as a Case Study for a Sustainability Rating System

LEED is an internationally recognised green building rating system developed by US Green Building Council (USGBC). LEED is intended to provide building owners and operators with a concise framework for identifying and implementing practical and measurable green building design, construction, operations and maintenance solutions. It recognises the best-in-class building methods and practices. To be awarded LEED certification, a building must meet a set of prerequisites and achieve a number of points; the minimum is 40 points and the maximum is 100 points, with an additional 10 points for innovation in design (USGBC, 2014b).

The LEED rating system is a tool that can help create a space that will enhance the everyday environment of clients, employees, or students, while reducing operating and maintenance costs and decreasing environmental impact. The features of LEED are:

- LEED provides third party verification that a building or community is designed, built and operated in a sustainable way
- voluntary certification system
- developed with a consensus-based approach
- LEED rating systems are developed based on triple bottom line:
- social responsibility (people): Better living conditions of people
- environmental stewardship (planet): Less impact on environment
- economic prosperity (profit): Reduce the lifecycle cost of building.

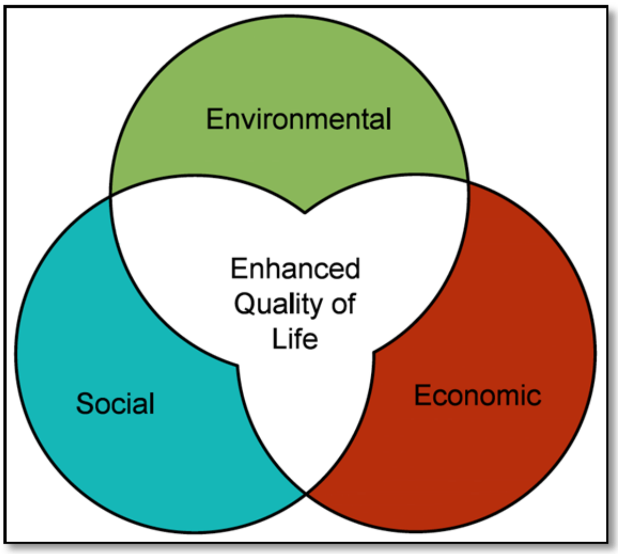

Figure 3.20. LEED triple bottom line, adopted from (Green Building Academy, 2014).

A typical score in the LEED rating system is composed of 100 credit points, with 10 additional points that can be attained if the project scores points in the Innovation in Design and Regional Priority categories, making the total achievable points 110. Table 3.1 illustrates the certification levels of the LEED rating system, where the basic level that is certified consists of earned points from 40 to 49. The second level is LEED Silver, which is earned by achieving between 50 to 59 points. The third level is LEED Gold, which is achieved if the project earns between 60 and 79 points. The highest level of the LEED certification system is LEED platinum, which is earned if 80 points or more are achieved. All certification levels have a certification fee that is paid to the Green Building Certification Institute (GBCI), but if the project receives a platinum seal, the certification fee is reimbursed. Table 3.2 shows the possible points that can be earned in each LEED category in any project.

Table 3.1

LEED Certification Levels (USGBC, 2014b)

LEED Certification Level	**Level points**
Certified	40-49
Silver	50-59
Gold	60-79
Platinum	80 points and above

Table 3.2

LEED Points Distribution (USGBC, 2014b)

LEED categories	**Possible points**
Sustainable site	26
Water efficiency	10
Energy and atmosphere	35
Materials and resources	14
Indoor environment quality	15
Total	100
Innovation and design process	6
Regional priority credit	4

The USGBC is responsible for developing the LEED sustainability rating system. The GBCI is responsible for certifying buildings and people. Both USGBC and GBCI are linked with LEED online. ‘The main roles of USGBC, GBCI and LEED online are illustrated below:

- USGBC is responsible for developing rating systems, reference guides and education programs.
- GBCI administers building certification and professional accreditation.
- LEED online is an online tool through which entire LEED Certification is handled.
- It is an online storage system where all details (credit templates, drawings, supporting documents, etc.) for LEED documentation are stored.
- Project Team gets access to Credit Interpretation Request (CIR) database, rating system errata, etc. Through LEED online.' (Green Building Academy, 2014).

Why should a project pursue certification when it can just apply sustainable methods without going through the process of certifying the project? Essentially, there are three general reasons why building owners should seek certification: commitment, legitimacy, and marketability. Commitment to register the project through the USGBC's LEED Online system leads towards the design and construction of buildings according to the standards and requirements outlined by the LEED rating system. Legitimacy is provided because in the face of widespread 'green washing' (i.e., the attempt by businesses or individuals to mislead consumers as to the environmental practices of a company or the environmental benefits of a product or service), LEED Certification tells peers, clients and customers that the building's sustainable features have been verified by a third party to:

- promote energy conservation
- ensure a healthier indoor environment
- reduce its impact on the environment.

Marketability is gained because a LEED Certified building, such as a headquarters of a company, branch office, retail location, or

> elementary school, is a strong marketing tool to show the community that the organisation is committed to something greater than itself. It demonstrates that the organisation or individual was willing to make the extra effort to not only include those features, but also to have them confirmed and certified by a nationally and internationally recognised leader in the field (Studio4 LLC, 2014).

In Saudi Arabia, the LEED sustainability rating system is widely used. There are more than 320 projects so far in 2014 certified with LEED, which vary in their certification levels and project types. More than 270 projects are located in Riyadh (USGBC, 2014b). However, using LEED does not ensure the projects that have used it are fully sustainable. This is evidently true as argued by Attia (2013), who analysed the application of LEED on an Al Ghala affordable housing project located 22 km to the north of Al Layth city on Jeddah-Jizan road. Attia states:

> LEED proved that it can be utilised as a guideline to enhance the sustainability of an existing affordable housing unit … For climatic, social, cultural and technical reasons, many LEED indicators were found to be inappropriate or inapplicable in the Saudi context leading to unjustified loss of points. (2013, p. 241)

LEED was not designed for Saudi Arabia and several characteristics challenge the full application of LEED, including the following:

- climatic conditions
- geographical topographies
- natural and non-natural resource consumption
- government policy and regulation
- incorporating and understanding the culture values
- the importance of public awareness.

3.4.6 Estidama—an Arab Sustainability Rating System

As part of the global awareness on the importance of having sustainability, in 2010 an initiative, Estidama, was established by the Abu Dhabi Urban Planning Council to promote sustainability and enhance the quality of life. The term Estidama means sustainability in Arabic. The Estidama has four pillars that are illustrated in Figure 3.23 and are: environmental, economic, social and culture. The Estidama initiative developed the Pearl rating system, which consists of seven categories that rate the performance of a building throughout its lifecycle, all of which fulfil the four pillars of Estidama. These seven categories are detailed in Table 3.3; the table shows the categories and the possible achievable points for each category.

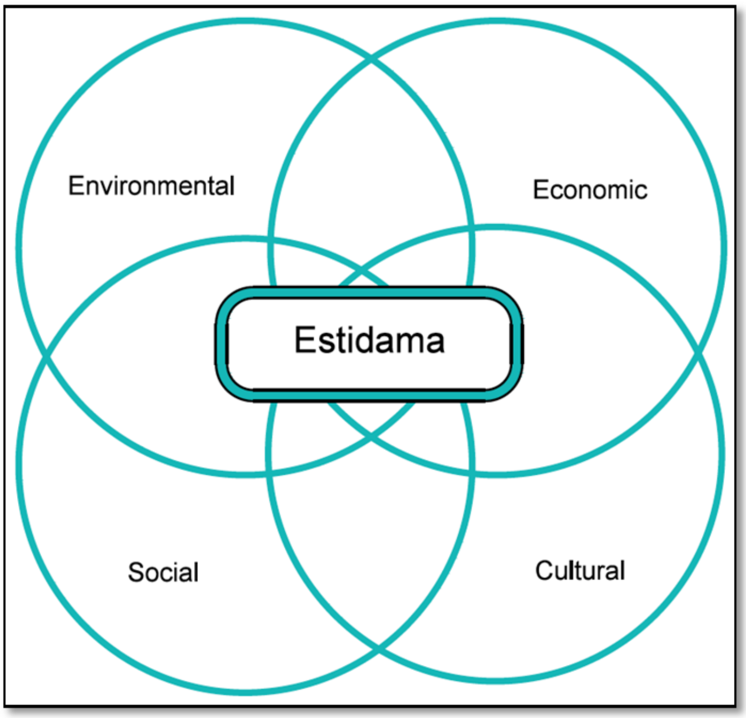

Figure 3.23. The four pillars of Estidama, adopted from (Abu Dhabi Urban Planning Council, 2010).

Table 3.3

Estidama Assessment Credit Distribution (Banani, 2011)

Estidama categories	Maximum credit points
Integrated development process	13
Natural system	12
Liveable buildings	37
Precious water	43
Resourceful energy	44
Stewarding materials	28
Innovation practice	3
Total	177

The Pearl rating system has five levels that can be achieved, ranging from one Pearl to five Pearls. The detailed requirements to achieve a certain Pearl level are illustrated in Table 3.4. An important issue to address in regards to the Pearl rating system is that it was developed to fit the local culture and weather of the UAE. This provides an example of what needs to be done in the KSA.

Table 3.4

Pearl Building Rating Levels (Abu Dhabi Urban Planning Council, 2010)

Requirement	Pearl rating achieved
All mandatory credits	1 Pearl
All mandatory credits + 60 credit points	2 Pearls
All mandatory credits + 85 credit points	3 Pearls
All mandatory credits + 115 credit points	4 Pearls
All mandatory credits + 140 credit points	5 Pearls

3.4.7 Comparing LEED and Estidama

To be able to comprehend the differences and similarities between the LEED sustainability rating system and Estidama for the sake of developing a Saudi sustainability rating system, it was imperative to carry out the comparison. The comparison can be seen in the following tables, where each item is checked against the two sustainability rating systems according to all categories. Tables 3.6 and 3.7 compare energy and water categories in detail.

Table 3.5

Comparison of Rating Tools Categories (Banani, 2011)

Category tool	LEED	Estidama
Energy	✓	✓
Water	✓	✓
Waste	✓	✓
Materials	✓	✓
Indoor environmental quality	✓	✓
Economics		✓
Management		✓
Mobility and transportation	✓	✓
Emission and pollution	✓	✓
Land use, site and ecology	✓	✓
Resources	✓	
Cultural and social	✓	✓

Table 3.6

Comparison of Energy Categories of Rating Tools (Banani, 2011)

Energy Category	LEED	Estidama
Energy Performance		
HVAC System	✓	✓
Lighting System	✓	✓
Transportation Systems	✓	✓
Hot Water System	✓	✓
Cost Reduction	✓	
Energy efficient Equipment	✓	✓
Energy Operation		
Monitoring	✓	✓
Emission reduction	✓	✓
Energy Resources		
Renewable Energy	✓	✓
Energy Strategies	✓	✓

Table 3.7.

Comparison of Water Categories of Rating Tools (Banani, 2011)

Water category	LEED	Estidama
Potable water consumption	✓	✓
Monitoring		✓
Leak detection		✓
Alternative sources	✓	✓
Irrigation Use	✓	✓
Grey water	✓	✓
Heat rejection		✓
Reduction landscaping	✓	✓
Water quality	✓	✓

From this comparison it is evident that the LEED sustainability rating system lacks some of the major items that relate to water management. This category is crucial to Saudi Arabia, due to the lack of renewable fresh water sources and heavy dependence on desalination plants to provide fresh water for the population. Estidama however, managed to tackle all of the water management categories. Conversely, Estidama did not manage to address the cost reduction element in the energy category while LEED did address it. Cost reduction is one of the key elements to achieve sustainability and it must be tailored to fit the local community to be sustainable. This leads to the conclusion that there needs to be a specific sustainability rating system for Saudi Arabia that relates to the local environmental needs alongside economic and socio-cultural needs as discussed earlier.

3.5 SUMMARY

It is evident that there are some specific issues and challenges facing the development and implementation of sustainable housing in Saudi Arabia. This is something of a phenomenon particular to current times—as the traditional vernacular style of architecture proved sustainable in the past in multiple ways, at a time in history before sustainability was a conscientious inclusion in our vocabulary and building designs. With the advent of rapid urbanisation, Saudi Arabia's housing industry has witnessed an unparalleled transformation to an architectural design that is not sustainable—culturally as well as environmentally. The traditional vernacular designs that were employed previously in Saudi Arabia took into consideration the environment by adapting an essential design that accommodated the harsh climate for comfort of the inhabitants, and construction materials were most generally taken from the immediate areas. This gave a special notifying signature to the structures according to the regions. In addition, the traditional vernacular designs respected the Islamic culture of the inhabitants by ensuring the privacy they required as per the directives of Islamic teachings. The designs also attended to the needs of the community by structuring neighbourhoods around a central *Masjid*.

However, regardless of how such findings are brought forth and publicised, little will be done to remedy this without official directives from governing bodies and the construction sector at large. It is evident that although Saudi Arabia does in fact have established building codes (SBC), more needs to be done to implement sustainability in the housing sector. This will be beneficial for the future in many ways, including the environment, the inhabitants, the economy, on the religious scope (as such ideals fall in line with the most basic of Islamic teachings) and marketability.

For any recommended plan or action, a system of checks and balance is usually considered the best manner of ensuring the success of such a plan. Even if building codes exist, such codes may not prove effective without a valid examination and rating system. The LEED system is the internationally reputable system for such rating—therefore, it should be implemented into the Saudi housing sector and building codes, albeit conformed specifically to the needs of the most conservative nation of the world (i.e., Saudi Arabia).

Chapter 4: Research Methodology

4.1 INTRODUCTION

The literature review structure designed for this thesis began from a wide perspective of the general background and the demographics of the investigated country, the KSA. The review narrowed down to the specific issues related to building codes and the role of the Saudi Government. The literature review, however, was split into two chapters. Chapter 2 discussed and defined sustainable housing and deliberated on the current problem facing the application of sustainable housing in Saudi Arabia. Chapter 3 moved to discuss more specific issues concerning the design of sustainable housing in Saudi Arabia, reflecting on the conservative Islamic culture of the country in addition to the building codes required to develop sustainable housing. In addition, there was a review on the role of the Saudi Government to develop and implement this building code.

This chapter first discusses the theoretical framework that establishes the methodology utilised in this thesis. The research data collection methods are discussed in detail. This thesis uses three data collection tools: semi-structured interviews, two Delphi rounds, and case study analysis. The analysis of the collected data utilises qualitative and quantitative approaches; both are elaborated in this chapter. Finally, the research quality is validated and tested against the research reliability and trustworthiness test.

4.2 THEORETICAL FRAMEWORK

From Chapter 2, sustainability was defined as the development that meets the needs of the current generation without compromising the needs of future generations. This development needs to interconnect three essential factors: socio-cultural, economic and environmental factors. Not meeting the three factors of sustainability leads to disequilibrium in the application of sustainability. Sustainability can be applied to all aspects of life, but this research focuses on housing in Saudi Arabia. Applying sustainability to housing development requires the collaboration of all key stakeholders from government, private and academic sectors of the country. This collaboration will eradicate any difficulties of applying sustainability to the housing development in the KSA, which includes vagueness of the definition of the term ‘sustainability’, lack of public knowledge of the benefits of applying this method of construction, and incentivise the building material market to produce sustainable building materials that the country desperately needs.

Multiple benefits of applying sustainable construction methods to housing in Saudi Arabia were discussed in the literature review that covered the three pillars of sustainability. These benefits include energy and resource conservation, pollution reduction, waste and environmental degradation, and the implementation of comfortable and healthy living environments. In a statistical manner, sustainable buildings can decrease energy consumption by approximately 30 per cent, water consumption by 30 per cent to 50 per cent, and 50 per cent to 90 per cent in overall cost savings. One of the staggering statistics found in the literature review was that buildings in Saudi Arabia consume over 80 per cent of energy for cooling purposes alone. This can quite immensely be reduced if sustainability measures are practiced, which can serve multiple benefits, one of which is the reduction in energy consumption, while the other is natural resource conservation. Sustainability measures were discussed in detail in the literature review, but it is worthwhile to elaborate on some of the measurements that can be undertaken to achieve sustainability in buildings in Saudi Arabia, which include:

- better insulation
- more energy-efficient heating, cooling, ventilation, and refrigeration systems
- efficient fluorescent lighting
- passive heating and lighting to take advantage of sunlight
- the purchase of energy-efficient appliances and electronics.

GCC countries are faced with unique challenges, as discussed in Chapter 2. The dominant challenges are related to energy consumption and depletion of natural resources. The overconsumption of energy and natural resources evident in GCC countries are mainly caused by rapid population growth and high urbanisation levels. GCC countries sought to solve part of the natural resource depletion problem, water scarcity, by building desalination plants that produce fresh water to the region. This solution might seem harmless, but these desalination plants consume large sums of energy powered by non-renewable sources. In reality, it is a vicious cycle or the 'Perfect Storm'. Natural water harvesting methods must be mandated in all buildings in the region to reduce the need for desalination plants, or at least increase the number of desalination plants that are powered by renewable energy sources. In a period of 20 years, GCC countries have rocketed in energy consumption from just over 200,000 GWh in the year 2000 to nearly 700,000 GWh, which is more than triple the amount. However, it is uplifting to see that GCC countries are taking several sustainability measures to ensure long-term sustainable growth. Such measures include:

- proposing energy efficiency measures and techniques
- capitalising on renewable energy and clean fuel supplies
- increasing water efficiency by using water efficient fixtures
- financing new renewable energy powered water desalination plants and increasing capacity
- buying or leasing agricultural land abroad.

From the literature review, it was evident that several predicaments are causing the housing industry in Saudi Arabia to fall short in providing adequate sustainable and affordable housing. Such predicaments include high rate of urbanisation, rapid growth in cities, infrastructure demand exceeding development, absence of defined boundaries for the city, and lack of laws against those who penetrate the city boundaries. These are not the only difficulties facing the Saudi housing industry. Environmental, economic and social challenges are also causing complications in the Saudi housing industry. Environmental challenges are evident in the climatic harsh conditions of the country that require vast sums of energy to make the indoor environment of any building comfortable for its inhabitants. This has created a consumption rate of 4.5 hectares of ecological footprint per person, which is roughly twice the world average. Economic challenges are quite surprising in an oil-rich country but, as in any country, small numbers of individuals have access to adequate housing while the majority is left with inadequate housing that depends heavily on their financial status. What is more, the ratio of renting compared to owning property in Saudi Arabia is very high, with about 70 per cent of residents living in rented housing. Saudi property developers are reluctant to build sustainable and affordable projects because of near-to-non-existence of mortgage financing, hence a further increase in the housing deficit as compared to the needs of the community.

The climatic, economic and cultural conditions of Saudi Arabia are unique. The KSA needs to be studied, analysed and respected for the uniqueness it is characterised for. Cultural uniqueness is found in the conservative Islamic culture of the population, which was elaborated in detail in chapters 2 and 3. Such cultural background needs several design aspects to be respected and implemented, including segregation between male and female sections of the house, achieving privacy between the public and the private, and being relatively close to a Masjid. Vernacular architecture of the country achieved all cultural aspects and provided a healthy environment for its inhabitants to live and thrive, but Westernisation shifts that spread through the country after the ‘oil-boom’ phase changed the Saudi neighbourhood and most of these design aspects were neglected. A middle-ground solution is possible if vernacular architecture methods are blended with modern designs. Addressing the crucial design aspects discussed in Chapter 3 can provide sustainable houses for the Saudi population, inspired by the traditions and cultural beliefs of the country. The following chart illustrates the outcomes from the literature review.

4.3 METHODOLOGY

To achieve the outlined objectives and to answer the research questions, a qualitative research method was used; it best fits this research due to its interpretivist nature. Qualitative research is an interpretation by the researcher of how the social world is and how it is understood and experienced. The data are collected from a social context where the researcher is flexible yet sensitive to the collected data; the qualitative approach is mainly about generating a comprehensive knowledge on data that is contextual, detailed, and rich. Additionally, qualitative data are about engaging the participants in conversation, interviews and surveys that are conducted in a natural relaxed setting that is in contrast to research conducted in a laboratory or controlled environment (Skulmoski, Hartman & Krahn, 2007). Further, qualitative research is oriented towards investigating a concept or a phenomenon in a descriptive manner form to participant's point of view in the contextual world in which they experience this concept or phenomenon (Waltz, Strickland & Lenz, 2010).

The methodology utilised in this thesis uses a combination of primary and secondary data. The primary data employ a combination of semi-structured interviews with experienced practitioners, two rounds of Delphi study among industry professionals, and case study analysis of real-life projects. The secondary data support the findings of the primary data by analysing relevant literature on sustainability and sustainable housing to support the argument. This chapter is the core of the thesis where the main drive of the research is explained, starting with the research methodology. In addition, the research approach and rationale are discussed. Section 4.3 focuses on the research data collection methods used in the thesis where the three methods used in this thesis are conversed in more detail. Section 4.4 discusses the data analysis approach and how the qualitative data were analysed and the use of Statistical Package for the Social Sciences (SPSS) to aid in the analysis of the quantitative part of the data. Finally, section 4.5 discusses the validity of the research and the reliability and trustworthiness of the data, followed by a chapter summary.

A series of decision-making choices regarding the data collection methods and analysis is involved in the research design from the outset of the research. Figure 4.1 illustrates the link between the research questions and objectives and links them to the research data collection method that answers that research question. This research aims to investigate and interpret the theoretical and practical knowledge on challenges facing the application and implementation of sustainable housing in Saudi Arabia. Additionally, this research aims to construct meaning through an interpretation and understanding of the participants' theories, experiences and knowledge, hence it is considered qualitative research. The participants' views are critical to forming the findings of this research and stipulate a specific and locally constructed reality. Thus, within the continuum of paradigms, this research fits within the interpretivist paradigm. Staller (2010) defines qualitative research as:

> An umbrella term used to cover a wide variety of research methods and methodologies that provide holistic, in-depth accounts and attempt to reflect the complicated, contextual, interactive, and interpretive nature of our social world. (p. 1159)

Staller (2010, p. 1159) continues to add that 'Most qualitative research starts from a constructivist epistemological position and from one of a variety of theoretical perspectives, such as interpretivist, feminist, or critical inquiry'.

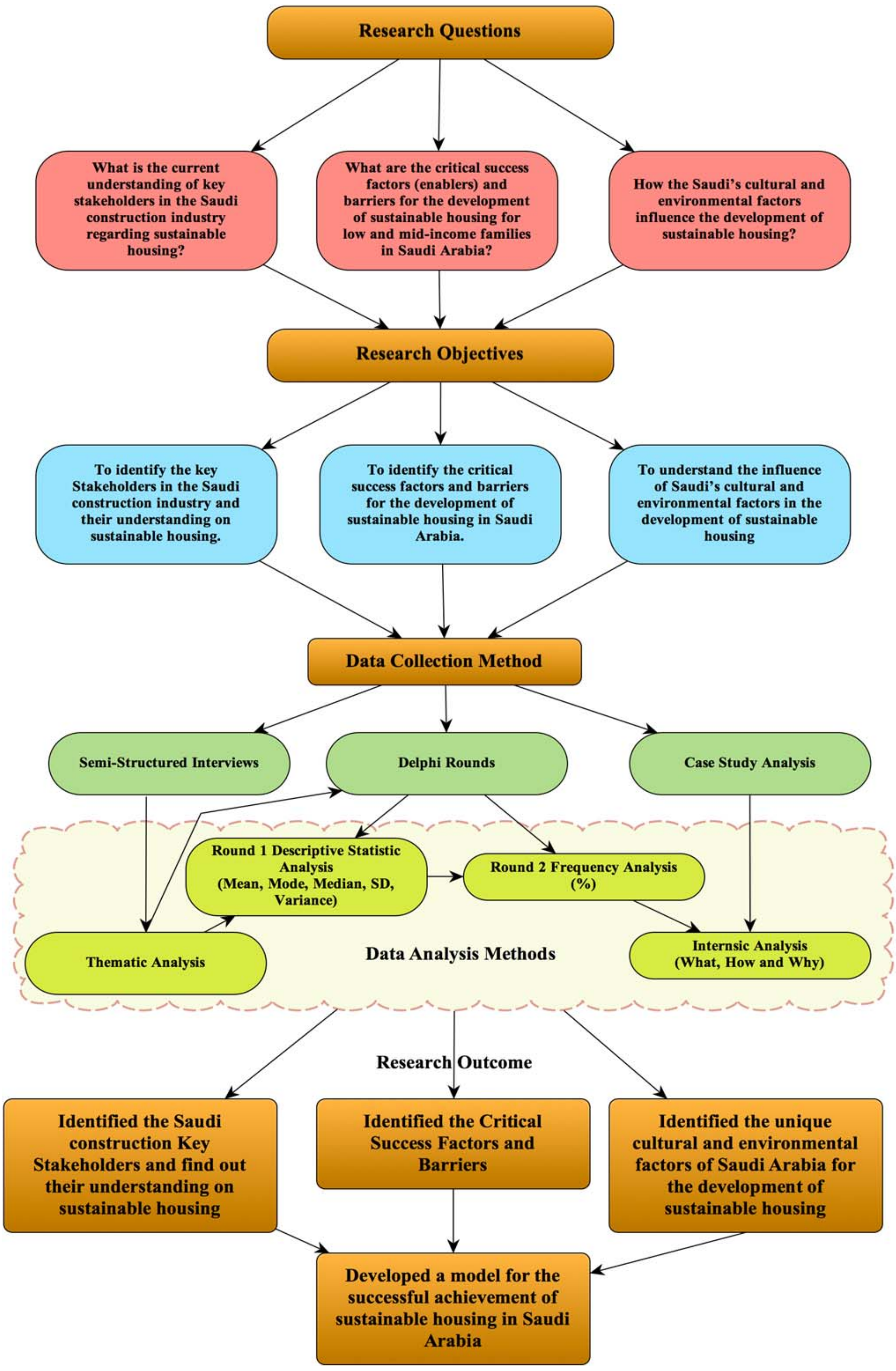

Figure 4.1. Research methodological framework: a graphical representation of interconnection of all stages and three techniques of the PhD research.

The complexity of the questions and the desire for practical outcomes useful in the ‘real world’ suggest the use of qualitative methods to ensure ‘rich’ data collection. Qualitative research enables a true-to-life revelatory research approach, allowing comprehensive descriptions and experiences to be congregated (Guba & Lincoln, 1994). Further, it facilitates the profound and meticulous study of issues through the use of open ‘what’ and ‘why’ questions (Denzin & Lincoln, 2005). However, most importantly:

> The empirical evidence used in qualitative inquiry is non-numeric and is collected in one or more of three basic forms: through *interviews and/or conversations* (either one-on-one or in groups), through *observations* (either unobtrusive or as a participant), and/or through *documents and artefacts* (either preexisting or generated as part of the research process). (Staller, 2010, p. 1161)

There are several reasons for selecting a qualitative approach:

- There is lack of information on the issue that is being investigated and limited research is available on the research topic.
- The area of research is considered new and/or evolved from previous research, so previous research or data no longer fit the phenomenon or concept.
- The research is an exploratory/descriptive research of a certain phenomenon or concept.
- Based on the phenomenon or concept under investigation, quantitative measurements are just not suitable (Waltz et al., 2010).

Research method and research methodology are not the same thing according to Adams, Khan, and Raeside (2007). The science and philosophy behind any research is what the research methodology, while the way of conducting the research and implementing the data is known as the research methods. The research methodology of this research consists of three main phases of work: the literature review, data collection, and data analysis. The outcome of the research is the formulation of a model that can to generate factors/elements for use in the future in a sustainability rating system (Adams et al., 2007).

The research method utilises the Delphi study with experienced professionals as the main research method for its primary data. Delphi is a qualitative technique that aims to attain group consensus while avoiding the hazards of face-to-face interactions (Rowe, Wright & Bolger, 1991). According to Skulmoski et al. (2007):

> The Delphi method is well suited to rigorously capture qualitative data. It may be seen as a structured process within which one uses qualitative, quantitative or mixed research methods. Such flexibility not only affords the ability of the method to answer many research questions, but also can be well matched to the abilities and aptitudes of the graduate student. (p. 9)

4.3.1 Research Approach

Throughout the literature, numerous scholars have discussed the appropriate way to conduct research based on the science taken by the researcher. There are two main research methodologies: deductive and inductive research. This research follows an inductive approach, where according to Yin (2009), an inductive research is one that constructs a theory from a number of observations. In contrast, the deductive reasoning approach is when a theory is subjected to a serious of rigorous tests. Several reasons validate the use of inductive reasoning over deductive and one main reason is limited empirical research in the area of research carried out (Yin, 2009), and there is lack of empirical research in the challenges facing sustainable housing in Saudi Arabia. However, the two methods complement each other if the data cycle is complete. According to Eisenhardt and Graebner (2007):

> Inductive and deductive logics are mirrors of one another, with inductive theory building from cases producing new theory from data and deductive theory testing completing the cycle by using data to test theory. (p. 25)

Accordingly, this research complements the mainstream deductive theory testing approach by generating the challenges facing the development and implementation of sustainability in housing in Saudi Arabia based on empirical evidence that can be tested by future deductive research.

4.3.2 Rationale of the Research

This research utilises the qualitative approach using mixed methods to generate validating data to achieve the research objectives. Several characteristics differentiate qualitative research from a traditional quantitative research:

- It uses an inductive approach.
- The participant's view is the principal of the data by showing how these participants make sense of their world.
- It is carried out in a true-to-life setting where the surrounding environment is not controlled as in a laboratory.
- The researcher is part of the data collection and is used as a tool to collect and analyse the data.
- It is the researcher's job to distinguish between the reality of the participants and that of his/her own, while keeping it close enough to the participants' world to be able to describe it and comprehend it (Waltz et al., 2010).

4.4 RESEARCH DATA COLLECTION METHOD

Attempting to validate and enhance the credibility of this research, the data collection and analysis will use the triangulation method. This is done by using multiple methods of collecting and analysing the data (Hastings, 2010). Stiles (1993) states that triangulation is merely gathering information from multiple data sources and using multiple methods. The first method is by conducting a semi-structured interview. The second method is by conducting two rounds of Delphi method. The third method is analysis of real-life case study projects that have applied sustainable construction methods and comparison with projects built in the traditional non-sustainable way.

Triangulation, according to Hastings (2010), is mainly used in qualitative research, where it involves gathering and analysing data from interviews, focus groups, surveys or other sources. Additionally:

> Triangulation is typically perceived to be a strategy for improving the validity of evaluation findings; a strategy that will aid in the elimination of bias and allow the dismissal of rival alternative explanations of conclusions and propositions. (Triangulation, 2005, p. 424)

The specific type of triangulation utilised in this thesis is methodological triangulation, as defined by Hastings (2010) as:

> *Methodological* triangulation, which is the most commonly used form of triangulation, engages multiple methods to study a single problem. Typically employed to compare data collected through qualitative methods with quantitative data, methodological triangulation can establish the degree of compatibility between information obtained through different strategies. (p. 1537).

4.4.1 Public Awareness Online Survey

The thesis began with a publication on the level of awareness of the Saudi public on the challenges facing the application of sustainability to housing projects. The survey generally indicated that there is lack of public awareness of this issue and going forth to ask the public on more detailed questions found to be unsuitable. Some of the outcomes were discussed in Chapter 2 and more detailed outcomes and discussion can be found in Susilawati and Al Surf (2011), presented in Appendix E.

In the final stages of the research, and after four years, another online survey was distributed to a random sample of the Saudi population that validated the necessity of asking the experts. This survey was sent in July–August 2014 through various online social networks including Twitter, Facebook and LinkedIn. A total of 1300 responses were gathered and analysed. The survey was very simple and short and consisted of six questions; the main aim was to reconfirm the lack of public awareness. The SGBC has conducted annual forums since 2010 and even after four years, the public's level of awareness of sustainability is high; they are not aware of any sustainable projects in Saudi Arabia. This means that further effort is required to get the public.

The first three questions were of demographical nature: sex, age and location of the participants in Saudi Arabia. The results show that 56 per cent were male participants and 44 per cent were female. The age of the participants varied but the majority was between the age of 25 and 34 (43.9 per cent). Some 29.6 per cent of participants were between the age of 35 and 44 years, and 11 per cent were between the age of 45 and 60 years. The remaining 15 per cent were either under 15 years

(14.5 per cent) or over 60 years of age (1 per cent). Figure 4.2 illustrates the age groups in a graphical format.

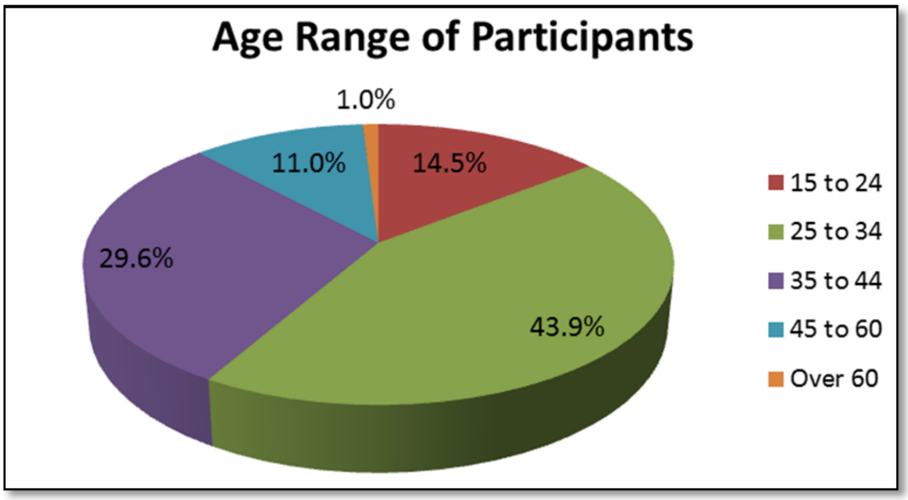

Figure 4.2. Age range of participants in the second online survey.

The results show that over 67 per cent of participants do not know what sustainable housing means and over 88 per cent do not think that there are any sustainable housing projects in the country. However, encouragingly, the participants were asked to select one of the sustainability factors listed in Table 4.1 below and the answers were positively aimed towards sustainability. The results show that the three highest selected sustainability factors that would be applied in a sustainable house are energy conservation, using renewable energy sources and water conservation.

Table 4.1

Sustainability Factors Selected by Participants in the Public Awareness Survey

Sustainability factor	**Number of responses (n=1300)**	**Percentage of total responses**
Energy conservation	633	48.65%
Water conservation	487	37.43%
Use of renewable energy	617	47.43%
Having at least 10 service within walking distance such as schools, etc.	340	26.13%
Using building materials sourced or manufactured within a radius of 800 km of project site	184	14.14%
Incorporating the cultural aspects such as segregation and privacy	208	15.99%
Reducing CO2 emissions	478	36.74%
Windows' optimal location in a house reduce the use of conventional AC	460	35.36%
Collecting and treating rain water to be used in toilets or irrigation	388	29.82%
Providing a comfortable indoor environment increases the productivity of the residents	356	27.36%
Using building materials that do not produce volatile organic compounds	530	40.74%
I don't know	271	20.83%

These percentages illustrate how lack of public awareness is a big impediment in the face of development of sustainable housing projects in Saudi Arabia. Hence, due to lack of public awareness as verified by the two online surveys, it was imperative to seek the answers from experts using the three data collection methods discussed in this chapter. The outcomes can be found in chapters 5, 6, and 7.

4.4.2 Semi-Structured Interview

This research aims to investigate and interpret the theoretical and practical knowledge of challenges facing sustainable housing in Saudi Arabia. In addition, this research aims to construct meaning through an interpretation and understanding of the participants' theories, experiences and knowledge of real-world situations. The participants' views are critical to forming the findings of this research and stipulate a specific and locally constructed reality. The semi-structured interviews were conducted with experienced professionals and are considered the first research method for the primary data. The questions were open-ended, but time allocation to each question was considered. The participants had a chance to comment and state their thoughts on issues, such as the critical success factors and the barriers to the challenges facing sustainable housing in Saudi Arabia. Interviews, according to Staller (2010, p. 1161):

> can be unstructured, semi-structured, or structured (although this is rarely favored). Questions are usually open-ended and seek to give the participant an opportunity to answer fully. Their purpose is often to explore meaning, understanding, and interpretations rather than to treat the interviewee as a vessel for retrieving facts. Interviews can be conducted with multiple individuals, such as in focus groups. They are often audiotaped or videotaped. These tapes can then be transcribed (using any number of different formats and transcription techniques) for easier analysis. (p. 1161)

According to Persaud (2010), interviewing is a very important method that can be used in qualitative and quantitative research. The form of the interviews range from completely structured to completely unstructured with semi-structured interviews in-between. This allows the flexibility of an unstructured interview but has some rigidity and constraints to control the direction of the interview. Interviews can be conducted using several methods, including face-to-face, telephone, email and videoconferencing via programs such as Skype.

4.4.2.1 Reason for Conducting a Semi-Structured Interview

The semi-structured interview was considered the stepping-stone of the data collection phase of this thesis. It was designed to be part of the Delphi rounds where the main reason for conducting the semi-structured interview was to formulate the questions for the first Delphi round. As Franklin and Hart (2007, p. 237) state: 'One limitation of the policy Delphi is the difficulty in developing an accurate initial questionnaire to start the process'. Skulmoski et al. (2007) pointed out the importance of conducting a pilot Delphi study by arguing that the pilot Delphi study, in this case the semi-structured interview, is carried out to test the first round Delphi questionnaire and adjust it if necessary. It is also important for inexperienced researchers to start the Delphi rounds by conducting a pilot study so avoid being ambitious regarding the scope of their research. The inexperience of some researchers leads to miscalculation of the time it will take participants to respond to the Delphi round questionnaires. In such situations, this can have catastrophic consequences if the deadline for the researcher is approaching. In order to develop the Delphi round questions, the semi-structured interview method was a necessity. The results from the semi-structured interviews formulated the questions asked in the first Delphi round. In addition, the approached participants were the first contact to extend the number of participants for the first Delphi round.

In addition to the above stated reasons, Persaud (2010) points out several reasons for conducting interviews that are face-to-face or even by telephone:

- The response rate is much higher in interviewer-administered surveys than in self-administered surveys. This is mainly because people generally feel embarrassed to turn down an interviewer who is on the telephone or at the doorstep, but they do not feel that way when a survey comes in the mail.
- Some interviewees may not know how to answer a question and the interviewer usually gets the ‘do not know’ answer, so having the interviewer on the telephone or in front of you will help get a more specific answer.
- Face-to-face or telephone interviews can help answer unclear questions.
- The interviewer has the advantage to get further insight into a specific question and obtain more in-depth answers.

4.4.2.2 Semi-Structured Interview Participants

Nine professionals agreed to participate in the semi-structured interview that was conducted as a pilot study at the beginning of the research. Ten questions ranging from broad themes to more specific issues, the first of which were very general in nature, asking of the participant’s work experience and relation to the construction industry. The participants ranged from academics to government workers to professional practitioners; their profiles and the questions asked can be seen in Chapter 5.

4.4.2.3 Panel Selection Criteria

Careful selection of the panel is necessary to the success of the semi-structured interview. The objective is to maximise the outcome while maintaining objectivity and remaining unbiased (Waltz et al., 2010). Several factors were considered for the selection of the panel members, whereas they should be:

- established practitioners/stakeholders considered knowledgeable by the housing construction sector with extensive working experience in housing construction projects for low- and middle-income households in Saudi Arabia
- experts who have been directly involved in housing projects (either currently or recently) with a sustainability focus
- experts who are in decision-making roles in an organisation or company associated with sustainable housing projects
- knowledgeable of the local possibilities and restrictions relevant to the implementation of sustainability to housing
- unbiased in respect to sustainable housing policy options and criteria, enabling viable solutions when faced with barriers.

4.4.2.4 Semi-Structured Interview Process

Designing the semi-structured interview questions was the first step in the design process of this data collection method. The questions were derived from the gap defined from the literature review and from the first online survey based on the three pillars of sustainability, economic, environmental and socio-cultural, with a fourth element as discussed in the literature review: application challenges. The questions were designed according to these four elements. The questions were structured to cover part or all of the four elements.

The first question is a general question related to the participant's work experience. It was important to know the level of experience with sustainable projects. The second and third questions related to the general background of the definition of sustainability and the factors related to it. The fourth and fifth questions are related to the enablers, barriers and factors listed in these two questions, derived from the literature review and the first online survey

The semi-structured interview was conducted online using mainly Skype. The participants were approached by email invitations. The participants, when they had committed to the research, were sent an agreement form to get their approval to participate, which took approximately two months. After that, the time was allocated depending on the availability of each participant and the interviews were successfully conducted through Skype. Finally, the analysis of the responses was the last phase of the process and the outcomes formulated the first Delphi round.

4.4.2.5 Semi-Structured Interview Limitations

As with any data collection method, there were limitations to the development and the execution of the interviews. One of the limitations was that the participants were reluctant to participate at the beginning when approached because they were not sure what they would gain out of participating, and they were not sure of the content that was going to be asked of them. However, after a connection was made with the participants by telephone and the process and content were explained, the interviews were conducted via Skype. The second limitation was that the interviews were conducted over the internet using Skype, which in some instances was difficult due to technical obstructions that at times affected the interview. When the connection failed and several attempts were made to reconnect, the interview was then continued by telephone call, which lacked the face-to-face advantage. Other limitations and disadvantages were discussed by Persaud (2010):

- Answers may not be accurate because interviewees have to give real-time answers.
- The interviewer must have good communication skills to draw answers from the interviewees.
- Interviewer-related effects can be the result of inappropriate interview management and interviewer characteristics, which can affect the results from the interview.
- Face-to-face interviews tend to have high cost of administration compared with self-administered surveys.

4.4.3 Delphi Method

The Delphi technique applies experts' opinions and inputs through a series of questionnaires and provides feedback to the experts to reach their consensus on a particular topic. This is usually done over two or three rounds (Chia-Chien Hsu, 2010; Hanafin, 2004; Linstone & Turoff, 2002). This methodology was first used by the RAND (Research and Development) Corporation for the American military in 1944 for technology forecasting studies (Hanafin, 2004). The Delphi method can be defined as:

> A research approach used to gain consensus through a series of rounds of questionnaire surveys, usually two or three, where information and results are fed back to panel members between each round. (Hanafin, 2004. p. 4)

Delphi is also defined by Linstone and Turoff (2011) as ‘A technique to apply expert input in a systematic manner using a series of questionnaires with controlled opinion feedback’. McCoy, Thabet, and Badinelli (2009) state:

> The Delphi method acquires the opinions of experts through a series of surveys. The responses to each survey are returned to the researcher who summarises them and reports to each panel member all of the opinions expressed by the panel. However, these reports are anonymous so that the pitfalls of ego, domineering personalities and the ‘bandwagon or halo effect’ in developing consensus are avoided. (p. 118)

The Delphi method utilised in this thesis is considered the core research method that answers the research questions and achieves the research objectives. In a Delphi process, experts state their opinion anonymously, thus encouraging them to express a more individual view rather than a prudently constructed official position (Masser & Foley, 1987). Masser and Foley (1987) discuss the nature of a Delphi method by affirming that:

> Delphi is a systematic method of collecting opinions from a group of experts through a series of questionnaires, in which feedback of the group’s opinion distribution is provided between question rounds while preserving the anonymity of the responses. (p. 217)

Experts are qualified through their knowledge, skill, experience, training and education; therefore, to select the experts for this research the following factors were considered:

- knowledge of affordable sustainable housing and the surrounding debate

- experience and involvement within the field of affordable sustainable housing in Saudi Arabia
- knowledge of the local capabilities
- objectivity with respect to sustainable housing policy options and criteria.

4.4.3.1 Reason for Choosing the Delphi Method

Justifying the selection of one method of research over another is quite difficult, as no single method is perfect. There are numerous reasons that justify the selection of the Delphi method over other qualitative research methods. Perhaps the most influential reason for the selection of Delphi for this research is that when there is lack of knowledge about a problem or phenomena, the Delphi method is best suited (Skulmoski et al., 2007). The Delphi method is applicable where it has been proven in the published paper (Susilawati & Al Surf, 2011) that there is lack of knowledge about the problem by the public. There is a lack of accessible knowledge about the challenges facing the application and development of sustainable housing in Saudi Arabia. Additionally, for the purpose of using superior instruments to distil better information from the panel members, the Delphi method was considered the appropriate tool for collecting the data. Further, due to the difference in time zones and difficulty in gathering all participants for an interview or a focus group, the Delphi method was easily accessible by the participants at their leisure, affording them appropriate time to participate in the data collection of this thesis.

The Delphi method was selected to first document and assess the judgments of experts on a particular topic. Second, to explore, examine and apprehend knowledge held by professionals on that particular topic. Finally, to develop new ideas that can surface from the approached professionals and experts. Additionally, Delphi is desirable in that it does not require the experts to meet physically, which could be impractical for an internationally diverse panel of experts. Further, the Delphi study is flexible in its design, and amenable to follow-up interviews. This permits the collection of richer data, leading to a deeper understanding of the fundamental research questions (Franklin & Hart, 2007). The following also lists the reasons for selecting the Delphi method as the main method used in this thesis:

- This study is an investigation of the challenges facing the application and development of sustainable housing in Saudi Arabia. It requires knowledge from people who understand the different economic, social, and environmental issues related to it.

- A panel study most appropriately answers the research questions, rather than any individual expert's responses. Delphi is an appropriate group method, among other high-performing group decision analysis methods.

- The Delphi panel size requirements are modest, and with such an issue where panel members might not have the experienced knowledge, the Delphi method is suitable in such cases.

- Flexibility of the Delphi study in its design is one of the core reasons for its selection, because participants are amenable to follow-up interviews. This permits the collection of richer data, leading to a deeper understanding of the fundamental research questions.

- The multiple iterations, or 'rounds', allow participants time to reflect, modify or adjust their responses in following rounds.

- Anonymity gives the research more rich data because there are no confrontations and disagreements that are usually associated with groups that may be face-to-face (Chia-Chien Hsu, 2010; Grisham, 2008; Linstone & Turoff, 2002; Rowe et al., 1991; Rowe & Wright, 1999; Skulmoski et al., 2007).

4.4.3.2 Delphi Method Participants

For the Delphi rounds, 47 participants of three key stakeholders groups from the Saudi housing sector agreed to participate and were selected as panel members. They were carefully selected based on the same criteria discussed earlier in the semi-structured interview panel selection criteria section. The participants were specifically invited via email to participate. The research was introduced to each of them in the initial contact email. This email introduced the WCED definition of sustainability to the participants to get them on the same level of understanding of the term ‘sustainability’.

The participants were given a range of choices on a six-category Likert scale. The categories are illustrated in Table 4.2. The reason for choosing six choices for the participants is because such diversity is needed in this type of research and the researcher has chosen to limit input from the participants to either agreeing or not agreeing upon a certain question. The level of agreement can differ from strongly disagree to strongly agree, but the end result is that the participant either agrees or does not agree. This varying level of agreement is based upon the cultural background of the participants, where an undefined choice can cause the results to be unworthy; hence, the choices were either levels of agreement or disagreement only. Stening and Everett (1984) state: ‘Individuals have different tendencies to use certain types of responses: extreme, neutral, agree, or disagree’ (p. 151). The reason for selecting this type of scale is also reinforced in the statement by Wong, Peng, Shi, and Mao (2011) that participants:

> may be more reluctant to express their opinions strongly and that this may be reinforced if the odd number response format with a mid-

point option of ‘no opinion’ or ‘neither agree nor disagree’ is provided. This may undermine the quality of survey data because less variances or even inaccurate information will be collected.

Table 4.2

Rating of Answers

Rating description	**Strongly disagree**	**Disagree**	**Slightly disagree**	**Slightly agree**	**Agree**	**Strongly agree**
Rating value	1	2	3	4	5	6

4.4.3.3 Characteristics of the Delphi Method

The objective of the Delphi method from a group of experts is to minimise the negative effects of group confrontations and to acquire the maximum trustworthy consensus of opinion (Rowe & Wright, 1999). The Delphi method can be classified by four characteristics: anonymity, iteration, controlled feedback and the statistical aggregation of group response (Rowe & Wright, 1999). Linstone and Turoff (2002) characterise the Delphi technique by stating:

> Delphi may be characterised as a method for structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem. To accomplish this ‘structured communication’ there is provided: some feedback of individual contributions of information and knowledge; some assessment of the group judgment or view; some opportunity for individuals to revise views; and some degree of anonymity for the individual responses. (p. 3)

The following also enlists the main characteristics of the Delphi method:

- ‘It is a repetitive process. The experts must be consulted at least twice on the same question, so that they can reconsider their answer, aided by the information they receive from the rest of the experts.

- It maintains the anonymity of the participants or at least of their answers, as these go directly to the group coordinator. This means a group working process can be developed with experts who do not coincide in time or space and also aims to avoid the negative influence that could be exercised by factors in the individual answers in terms of the personality and status of the participating experts.
- Controlled feedback. The exchange of information between the experts is not free but is carried out by means of a study group coordinator, so that all irrelevant information is eliminated.
- Group statistical response. All the opinions form part of the final answer. The questions are formulated so that the answers can be processed quantitatively and statistically' (Landeta, 2006, p. 468).

The Delphi method requires a small number of participants to achieve the desired outcomes but that does not mean that the outcomes cannot be reliable or significant. Waltz et al. (2010) add that there is no fixed number to a Delphi study, but it depends on two main factors:

- A fewer number of participants is needed if as much data as possible are obtained from each participant.
- A larger number of participants is needed if the research topic is broad in order to reach saturation or redundancy.

For this reason, this thesis, conducted with 47 panellists in the first round, must be considered an indicative study of selected experts that does not represent in any way the total population of Saudi Arabia. Their opinions and answers to the survey may be used to formulate a set of rules and regulations that can then be introduced to the public for their input as to whether or not those set of rules and regulations can or should be applied. Further, the panellists have shared answers to the survey questions that are similar, so saturation can be a further reason for selecting this small number of experts.

4.4.3.4 Panel Selection Criteria

The Delphi participants, according to Skulmoski et al. (2007, p. 10):

> should meet four 'expertise' requirements: i) knowledge and experience with the issues under investigation; ii) capacity and willingness to participate; iii) sufficient time to participate in the Delphi; and, iv) effective communication skills.

For this reason, the participants were selected according to the knowledge and possible information that can be obtained from them based on their level of expertise in the Saudi construction industry. Additionally, the same selection criteria discussed in the semi-structured interview were used to select the participants for the Delphi method.

4.4.3.5 Delphi Method Process

The Delphi method is used to help a group of decisively selected experts come to a consensus regarding the answer to a question(s), particularly if the answer requires making predictions about the future. The process of the Delphi method is as follows:

- Select knowledgeable and expert panel members to answer a serious of questions.
- Send out the questionnaire to the panel members to obtain answers.
- The controller analyses the answers, looking for central and extreme tendencies, and their validations.
- The results are then fed back to the panel members.

- Panel members are then asked to resubmit their views, aided by the analysis provided by the controller.

- This process continues until the controller sees that a consensus has been reached Grisham (2008).

Figure 4.3 illustrates the process of a typical Delphi method as adapted from McCoy et al. (2009), and Figure 4.4 illustrates the process of the two-round Delphi process utilised in this thesis.

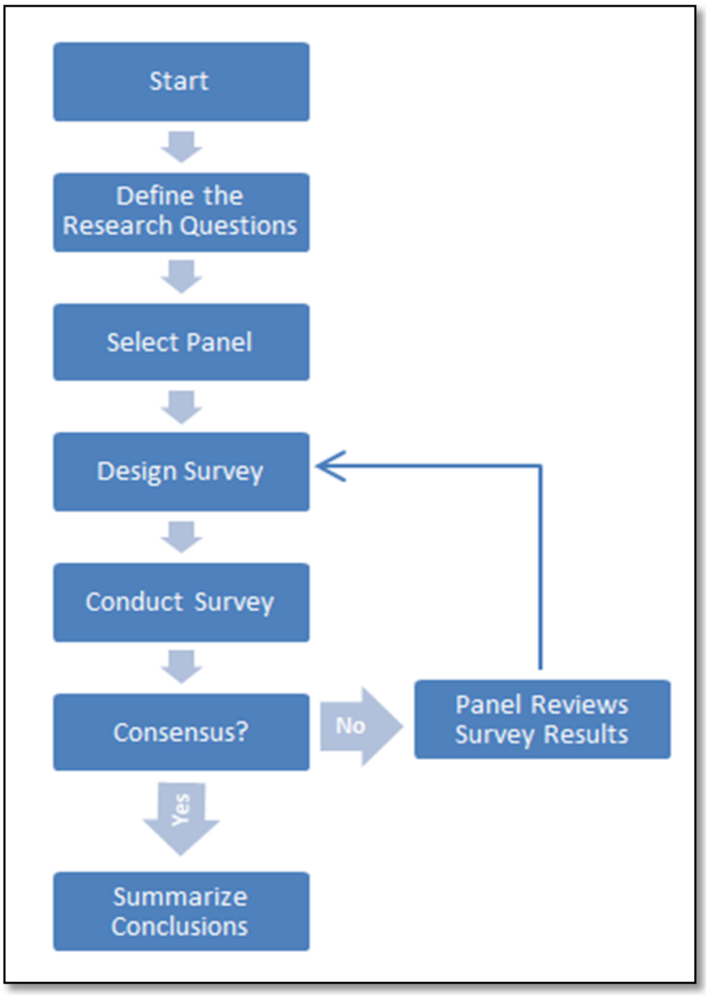

Figure 4.3. The process of a typical Delphi method (McCoy et al., 2009).

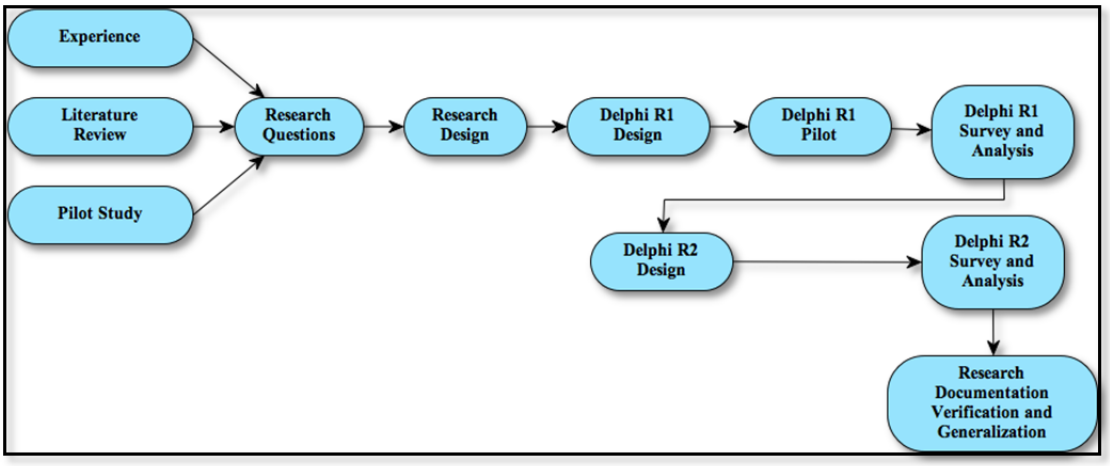

Figure 4.4. Two-round Delphi process (Skulmoski et al., 2007).

There is no 'typical' Delphi, but the Delphi process involves two or three iterations, or 'rounds' and in some cases single rounds have also been completed (Skulmoski et al., 2007). According to Chia-Chien Hsu (2010):

> The iterations mean a series of feedback processes. Due to the iterative characteristic of the Delphi technique, instrument development, data collection, and questionnaire administration are interconnected between rounds. As such, following the linear steps of the Delphi process is important to success with this technique. (p. 344)

The number of panel members varies according to the research undertaken. The method is adjusted according to the circumstances of the research and the research question(s). The initial Delphi round can start with either broad or narrow questions and can also begin with open questions (Skulmoski et al., 2007). It is worthwhile to mention that due to the nature of the selected panel members, some of them have high-ranked job positions and time constraints, two Delphi rounds were designed and distributed.

4.4.3.6 Delphi Method Limitations

Through the literature, scholars have disputed the use of the Delphi method due to several reasons, including:

- the basis on which an expert becomes qualified and selected as a panel member
- the limitation of interaction between panel members and the interaction involved in written and controlled feedback
- the continuation of answering surveys for the same research over and over again, which can cause some of the panel members to withdraw from answering future rounds
- the guidelines of reaching consensus that the researcher has laid out might not be deemed acceptable by the panel members
- the time required to reach consensus might be longer than anticipated, which can result in further delaying the outcomes form the Delphi rounds
- the constraint to the likelihood of social compensation for individual contribution.

4.4.4 Case Study Analysis Method

The third research method utilised in this thesis is the case study analysis of real-life projects that have applied sustainable construction methods and compare them with projects that built in the traditional non-sustainable way. This section discusses in detail the background of case study analysis, reason for conducting case study analysis, the process of conducting case study analysis, and the limitations of conducting case study analysis.

Case study analysis is considered a qualitative approach to research. It differs from quantitative research due its nature of observing a case study in the field and interpreting data from the field to the research. ‘Methodologies used in the interpretivist paradigm are mainly qualitative rather than quantitative, and often involve field work – that is, study of the phenomena under consideration in their natural setting’ (Oliver, 2004, p. 291). Yin (2009) defines case study as a study that investigates a phenomenon that is contemporary in its real-life context. Waltz et al. (2010) argue that the aim of the case study analysis is to get a comprehensive analysis of the case to learn lessons, and form naturalistic generalisations in a chronological way. Scholars in various fields and disciplines have given case study research various definitions and forms but according to Putney (2010), they all have one commonality between them—a case study is an inquiry about a bounded system.

4.4.4.1 Reason for Conducting a Case Study Analysis

One main reason for case study analyses in this research is that it is of an exploratory nature. Case study analysis provides answers to the questions ‘what’ and ‘why’ as discussed by Putney (2010):

> Exploratory case studies are those in which the research questions tend to be of the *what can be learned about this issue type*. The goal of this kind of study is to develop working hypotheses about the issue and perhaps to propose further research. (p. 118)

The case study method used in this thesis is considered to be an intrinsic case study analysis, which is defined by Putney (2010, p. 116) as ‘Case study researchers may choose to learn about a case because of their inherent interest in the case itself’. However, it is also considered a collective case study analysis because there will be multiple case studies to be analysed. Putney (2010, p. 117) argues that ‘If the intent is to study the reform in more than one setting, then the researcher would conduct a collective case study'. With this background, this thesis uses case study analysis to validate the applicability of sustainable housing in Saudi Arabia. The analysis validates the three research questions in general; it focuses on economic, environmental and socio-cultural aspects of sustainability, in addition to the application aspect of sustainability in real-life projects. The case studies validate and answer the research questions by focusing on energy and water consumption, which both have economic and environmental impacts. CO_2 emission is also analysed, which relates to the environmental aspect of sustainability. The socio-cultural aspect is analysed through the adaptation of the unique conservative culture of Saudi Arabia through the design of the case studies. The application aspect of sustainability is analysed through building materials that are sustainable and preferably local. It also links to the reduction of energy and water consumption through the use of certain materials. Further, building materials also contribute towards the economic and environmental aspect of sustainability.

4.4.4.2 Case Study Selection Criteria

As with the previous two data collection methods, careful selection of case studies is vital for the successful analysis of the answers to the research questions and achievement of research objectives. The case studies were selected based on the following:

- must be a housing project
- has applied sustainable construction methods in any or all phases of the building

- must be in Saudi Arabia
- has applied or incorporated building codes and regulations, Saudi or international
- availability of data to analyse
- willingness of case study owner to share information.

4.4.4.3 Case Study Analysis Process

There are multiple methods to conduct a case study analysis. However, Putney (2010) states that the researcher should begin the case study analysis with a monograph that tells a story of the time and place of the case study. The issues to be analysed and methods used are discussed in the next section. After that, a full description of the case study and context is detailed. Next, the researcher builds the complexity of the study from the issue described in the previous section. Evidence is then drawn from the case, where it may be correlated with other related research. Finally, the researcher presents the answer to the '*so what*' question. A summary of claims can be written and conclusions drawn from the understanding of the data.

In terms of the appropriate number of case studies, Waltz et al. (2010) claim that case study can be taken on one 'participant (i.e., individual, family, or organization)' or can have multiple case studies. Single case studies require more data to be collected through multiple interviews or other data sources. However, in multiple case studies, the data collected depends on how the case studies can be fully understood, which can mean collecting data from one data source or multiple sources.

4.4.4.4 Case Study Analysis Limitations

The case studies selected and analysed are chosen based on having been built on sustainable methods. Their performance is compared in terms of energy and water efficiency to projects built on non-sustainable methods. The limitations that faced the case study method were mainly the lack of sustainable projects with substantial data. Sustainability is considerably new in Saudi Arabia and the concept was first made public and adopted by the Saudi Government in 2010, so there were few projects since then that could be used as case studies for this thesis. Other limitations, aside from lack of projects, include limited available data of the selected projects, and the necessity for an extended period to obtain information from project stakeholders. For example, an attempt was made to collect data from other sustainable projects, such as the King Abdullah Financial District (KAFD) project in Riyadh and the Riyadh Technology Valley (RTV) project also in Riyadh, but the projects' contact personnel were hesitant to provide any data due to security concerns and sensitivity of the selected projects.

4.5 DATA ANALYSIS APPROACH

Data analysis differs according to the research methodology and varies if the research is qualitative or quantitative. Since this thesis is a qualitative oriented research, descriptive statistics will be the main method of analysing the data. Descriptive statistics according to Hinton, McMurray and Brownlow (2014):

> give us a way of accurately describing and summarising large datasets quickly and easily. The most common descriptive statistics used are the measures of central tendency (mean, median and mode)

and the measures of dispersion (the range, standard deviation, standard error and variance). (p. 35)

This section discusses in detail the approach used to analyse the collected data.

4.5.1 Analysing Qualitative Data (Descriptive and Thematic Analysis)

This research investigates and interprets the theoretical and practical knowledge of the panellists with regard to the challenges facing sustainable housing in a Saudi Arabian setting. This sets the stage for future studies of higher intensity. The analysis of the semi-structured interviews is done by conducting a thematic analysis of the collected responses after categorising the themes distilled from the interviews. The responses from the participants in the two Delphi rounds were also used and their quotes were incorporated into the research where appropriate.

4.5.2 Analysing Quantitative Data (Using SPSS)

Analysing qualitative research data can be tedious and the presented data may not be analysed appropriately. It was the aim at the beginning of the data collection stage of the thesis to utilise software that was capable of interpreting data from a qualitative perspective into a quantitative representation. Quantitative analysis software, such as SPSS, according to Jones (2007) has been the trend between researchers while qualitative research analysis programs have taken much longer time to become known. Even though qualitative research data can be analysed in a descriptive manner, having software that analyses the qualitative data can ‘provide tangible benefits’, and can also help in reducing the amount of time required to analyse the data. Having this software can also produce enhanced data accuracy and provides thorough interpretation and coding of data.

The analysis of the Delphi round utilises two methods of analysis; the first uses the mean, median, mode, standard deviation, and variance:

> The mean is simply the arithmetic average of a distribution of scores the median is the score in the distribution that marks the 50th percentile. That is, 50 per cent of the scores in the distribution fall above the median and 50 per cent fall below it. The mode simply indicates which score in the distribution occurs most often, or has the highest frequency. The standard deviation is the average deviation between the individual scores in the distribution and the mean for the distribution. The variance is the sum of the squared deviations divided by the number of cases in the population, or by the number of cases minus one in the sample. (Urdan, 2012, p. 11)

The second analysis of the Delphi rounds uses the frequency of the responses from the second round that results in either reaching consensus or not.

The goal of analysing qualitative data is to fragment blocks of data to interpret and code that data and merge it into conceptually and theoretically related categories, which later on establish the hypothesis and assumptions about the case or phenomenon being studied (Jones (2007). The process of analysing qualitative data involves a process of reduction to manage and classify data. Units of text are usually the first to be:

> de-contextualized by removing them from their source – with their meaning intact – and then re-contextualized by drawing from them a more robust, context independent, meaning based on an accumulation of evidence. (Jones, 2007, p. 67)

The aim of the data analysis in this thesis is to utilise SPSS and present the data in a quantitative manner to be more tangible and clearly understood.

4.6 RESEARCH QUALITY

Several methods determine the quality of the research and vary according to the research undertaken and the school of thought followed by the researcher (Eisenhardt & Graebner, 2007; Guba & Lincoln, 1994; Landeta, 2006; Staller, 2010; Stenbacka, 2001; Stiles, 1993; Yin, 2009). Accordingly, the quality measures used in this research look into validity, reliability and trustworthiness.

4.6.1 Validity

Validity, according to Stenbacka (2001, p. 551), simply means 'the intended object of measurement actually is measured'. According to Waltz et al. (2010), validity is the 'truth value' of the data being analysed or the level of relativity to reality presented by the findings. Stiles (1993, p. 607) also adds: 'Validity concerns whether an interpretation is internally consistent, useful, robust, generalizable, or fruitful'. Validity can be broken down into more detailed types: internal validity and external validity. Internal and external validity can be further broken down into positivistic assumptions, where five types of understanding and validity exist: interpretive validity, descriptive validity, generalisability, theoretical validity and evaluative validity.

There are concerns and threats to validity if interviews are used to collect data as argued by Waltz et al. (2010). The data collected from interviews can be influenced by the interviewer and the interviewee. This is because the situation is set by the interviewer, where questions are asked and the interviewee answers the questions asked by the interviewer. However, validity can be achieved by utilising triangulation, as is the case in this thesis. This research can also be validated by testing it against construct validity, as discussed by Yin (2014), where it uses multiple sources of evidence, establishes a chain of evidence, and has been reviewed by key informants or peers in the area of study through several conferences and journal papers. Research reliability is discussed next, but according to Waltz et al. (2010), although reliability in qualitative research is an essential requirement for validity, concentration is always focused on validity.

4.6.2 Research Reliability and Trustworthiness

Reliability is a very crucial characteristic to the quality of the research undertaken and according to Stenbacka (2001), the fundamentals of reliability is that the same research result can be produced over and over again. Waltz et al. (2010) concurs with Stenbacka (2001) and claims that consistency of the research results over time is the main characteristic of reliability. There are two means of measuring reliability according to Waltz et al. (2010): internal and external reliability. Internal reliability means that the research data generated by other researchers should be exact to a great extent to the original data generated by the original researcher. External reliability is the discovery of the same case or phenomena by independent researchers that generate the same results in the same or similar situation. Further, according to Sinkovics, Penz and Ghauri (2008), dependable, credible, transferable and confirmable data need to be established in qualitative research to form ‘trustworthiness’.

In quantitative research, reliability and validity are objects of fundamental concerns, but these concerns tend to be blurred according to Sinkovics et al. (2008). Several researchers argue that the use of such methods is misleading and not applicable in qualitative research (Guba & Lincoln, 1994; Landeta, 2006; Sinkovics et al., 2008; Stenbacka, 2001; Stiles, 1993). Additionally, Stenbacka (2001) argues that in quantitative research, the researcher and the method are seen as separate from each other while this cannot be the case in a qualitative research because the researcher is part of the methodology. The conclusion, as argued by Stenbacka (2001), is that if reliability is the main criterion of a qualitative study, then the consequence of that study is no good. However, being aware of this debate, this research will follow recommendations for improving the reliability of the findings and ensuring accuracy and meticulousness of the research process and results (Eisenhardt & Graebner, 2007; Sinkovics et al., 2008; Stiles, 1993; Yin, 2009).

This research can be tested against reliability and trustworthiness as key points discussed in the literature review regarding the challenges facing the application of sustainability to housing in Saudi Arabia. This has been discussed in all three data collection methods. Further, several authors have already discussed the need to apply sustainable construction methods on housing in Saudi Arabia to some extent covering some or all of three sustainability pillars (Abu-Ghazzeh, 1996; Al Naim & Mahmud, 2007; Al Rimmawi & Bhardwaj, 2007; Allen, Lucas, Manzi & Lloyd-Jones, 2010; Aluwaisheg, 2013; Assaf et al., 2010; Bhattacharyya, 2009; Champan et al., 2000; CIA World Fact Book, 2011; Dokoupil & Rashad, 2013; Eben Saleh, 1998; Henderson, 2002; Husain & Khalil, 2013; Jameel & Hafith, 2012; Karam, 2010; KAUST Industry Collaboration Program, 2013; Kinninmont, 2010; Mahmud, 2009; Malla, 2009; Medany, 2008; Miranda & Marulanda, 2001; Mubarak, 1999; Roberts, 2010; Roy, 2009; Samad & Bruno, 2013; Saudi Gazette, 2013; Savard et al., 2010; Stensgaard, 2008; Swain, 1998).

4.7 SUMMARY

In retrospect, the methodology of this research was qualitative, which was undertaken in an inductive approach. The reason for selecting this approach was rationalised in section 4.3 of this chapter. It is predominantly the result of lacking available information on the challenges facing the application of sustainability to housing in Saudi Arabia. Within the realm of the qualitative approach applied to this research, multiple methods of generating validation of data were employed in order to achieve the objectives of the research. The research methods, which were employed for gathering and examining data—semi-structured interviews, two Delphi rounds, and case study analysis, were selected for the impact that the effect of triangulation has upon the ultimate quality and validity and trustworthiness of the final results. The next chapters (chapters 5, 6 and 7) present the data and discussion from the semi-structured interviews, Delphi rounds and case studies.

Chapter 5: Semi-Structured Interview

5.1 INTRODUCTION

This research, as discussed in Chapter 4, aims to investigate and interpret the theoretical and practical knowledge of challenges facing sustainable housing in Saudi Arabia. In addition, this research aims to construct meaning through an interpretation and understanding of the participants' theories, experiences and knowledge. The participants' views are critical to forming the findings of this research and stipulate a specific and locally constructed reality. This thesis utilises a semi-structured interview with experienced professionals as the main research method for its primary data. The questions were open-ended; the participants had a chance to comment and state their thoughts on issues such as the critical success factors and the barriers.

Nine professionals agreed to participate in the open-ended semi-structured interview. There were a 10 questions ranging from broad themes to more specific issues, the first of which was of a very general nature: the participant's work experience and relation to the construction industry. The participants were approached by email invitations sent a few times to get their approval to participate, the duration of which took approximately two months from June to August 2012. However, there were limitations to the development and the execution of the interviews. The first limitation was that the participants were reluctant to participate when approached because they were not sure what they would gain by participating, and they were not sure of the content that was going to be asked of them. However, after a connection was made with the participants by telephone in which the process and content was explained. The interviews were then conducted via Skype. The second limitation was that the interviews were conducted over the internet using Skype, which in some instances was difficult due to technical difficulties that affected the interview. When the connection failed and several attempts were made to reconnect, the interview was continued by telephone, which lacked the face-to-face advantage. The participants ranged from academics to architects to government workers to private contractors, as can be seen in Table 5.1.

Table 5.1

Semi-structured Interview Participant Profiles

ID	M/f	Age	Current position	Education	Job sector
P-1	M	30–40	Director of research and assessment	Master	Private
P-2	M	30–40	Architect	Bachelor	Public
P-3	M	40–50	Architect	Master	Public
P-4	M	30–40	Architect (academia)	PhD	Public
P-5	F	30–40	Architect	Bachelor	Private
P-6	M	30–40	Architect (academia)	Master	Public
P-7	M	30–40	Consultant (academia)	PhD	Public
P-8	M	50–60	Contractor	Bachelor	Private
P-9	F	50–60	Consultant/advisor	Bachelor	Private

The following were the questions all nine participants answered:

1. Please state your work experience and relativity to the construction industry, including any sustainable projects (if any).
2. What is your interpretation of sustainable development, specifically in the housing industry (sustainability definition)?
3. What parameters/factors of sustainability do you account for when dealing with a housing project (the triple bottom line of sustainability)?

4. What are the critical success factors and/or barriers for applying sustainability to housing in Saudi Arabia and how can barriers be managed?
5. In your opinion, does the SBC discuss or relate to the cultural needs of the Saudi population and their unique cultural characteristics?
6. In your opinion, what environmental factors must be addressed in the design of a Saudi house to make it sustainable?
7. What features of the vernacular architecture of Saudi Arabia would you like to see back in today's Saudi houses, or do you even agree that they should be incorporated into the design of a house, for example, the wind towers, the Mashrabiya, the inner courtyards, etc.?
8. One of the crucial elements in the design of a Saudi house is it must provide privacy and be out of the sight range of passing pedestrians. In your opinion, how can we achieve privacy in a sustainable way in a Saudi house?
9. How can low- and middle-income families afford houses in the current Saudi real estate market, and how differently would you like it to be (if any)?
10. It is well known that the initial payment for a sustainable house is higher than a normal house. How can low- and middle-income families afford to pay for sustainable houses, and can the Government intervene in making it more affordable (i.e., incentives, grants)?

This chapter discusses the results and the findings from the semi-structured interview. Appendix A and B show the documents that were sent to the selected participants.

5.2 SEMI-STRUCTURED INTERVIEW RESULTS

The results of the semi-structured interview are discussed in the following subsections.

5.2.1 Related Work Experience and Sustainable Projects Results

The first question is:

Please state your work experience and relativity to the construction industry, including any sustainable projects (if any).

Table 5.2 illustrates the collected answers:

Table 5.2

Question 1 Response

Participant	**Years of experience**	**Worked with sustainable projects**	**Have knowledge about the subject**
P-1	8	Yes	Yes
P-2	12	No	Yes
P-3	12	Yes	Yes
P-4	10	No	Yes
P-5	3	No	Yes
P-6	6	No	Yes
P-7	12	Yes	Yes
P-8	32	No	Yes
P-9	15	No	Yes

For the first question, the participants had the chance to tell the researcher about their work experience and if they had any contact with sustainable housing projects. The outcome of the question was that three of the nine participants had been in contact with sustainable construction projects, and they were P-1, P-3 and P-7, as illustrated in Table 5.1, while the remaining six have not been in any contact with any sustainable project. However, from Table 5.2, it is evident that all of the participants knew about sustainability, which was a good indication of their level of knowledge. As shown in Table 5.2, it is evident that four of the participants, P-1, P-3, P-5 and P-7, have knowledge of the SBC, while the remaining five have no knowledge of it at all. This could be the result of the SBC not being introduced to the public or to the industry.

5.2.2 Sustainable Development Interpretation Results

All participants had a great deal of knowledge when it came to answering the second question, which was:

> What is your interpretation of sustainable development, specifically in the housing industry (sustainability definition)?

The participants highlight the important components of sustainable development, which are: environmentally friendly, low cost, energy efficient, use local resources and serve social-cultural needs. The participants' statements in response to the question are as follows:

> P-1: Sustainable development is achieved if it has no effect on the environment, has minimal cost and serves the society.

> P-2: It is a kind of housing which is useful for people because it is cheap and meet the needs of residents and functional, psychological and social requirements. These kinds of housing only require little effort and low cost for maintenance, cleanliness and operation.

> P-3: Sustainable (urban) development means **continued independence of its structure on the city**, unlike other urban development heavy dependence and demand on infrastructure and adjacent urban facilities and services.

> P-4: A sustainable housing development is a development that is built from local materials, which are suitable for the local

environment and cultures while employing (absorbing) the local weather to for its advantage in energy efficiency.

P-5: Sustainability in the context of housing must deal with the **exterior environment**, acknowledging the sun heating patterns and adopting systems that **relate to the specific conditions of the climate**. It also means to look at natural patterns of rain, sun radiation and how to use these resources in everyday living. To be sustainable must also mean to consider humans' **basic agricultural needs**, so planting and gardening is another criteria. To be sustainable also means to **consider our** "trash", where do things end? Where do they come from again? Considering full cycles in the dwelling construction and habitation has been introduced lately **but not highly used by contractors and investors**.

P-6: The term sustainable can be sometimes misused in the field of architecture. Sustainable design means to **keep the environment as it was** before the erection of the building, which is impossible to achieve. However, the building or the development can be **eco-friendly** in a number of strategies. My definition of sustainable development is the development that uses the **local resources** and strategies with a minimum amount of **renewable energy** that will not affect or harm the **environment** for the future use.

P-7: I think that sustainable development is mainly the **conservation of resources** for the future generations. It is concerned with the **conservation of energy** resources for the longest possible period of time.

P-8: A sustainable housing development is a development that is environment friendly and conserves electricity, water and environment pollution.

P-9: Any housing, buildings, or other construction, which proves to be **environmentally friendly**, has low-cost, long-term maintenance and is **affordable** to the consumer.

Table 5.3 summarises the findings from the interview in a thematic format.

Table 5.3

Thematic Analysis of the Second Question from the Interviews

Theme	Participants									Total
	P-1	P-2	P-3	P-4	P-5	P-6	P-7	P-8	P-9	
Environmentally friendly	✓			✓	✓	✓	✓	✓	✓	7
Energy conservation			✓	✓	✓	✓	✓	✓		6
Cost reduction	✓	✓	✓					✓	✓	5
Renewable energy				✓	✓	✓	✓	✓		5
Affordable	✓	✓	✓						✓	4
Local material			✓	✓		✓				3
Respect culture	✓	✓		✓						3
Recycling					✓	✓				2
Low-cost maintenance	✓								✓	2
Lack of stakeholder involvement					✓					1
Mental wellbeing	✓									1
Independence of structure			✓							1
Total extracted themes	6	3	5	5	5	5	3	4	4	

5.2.3 Sustainability Parameters Results

The third question is:

What parameters/factors of sustainability do you account for when dealing with a housing project (the triple bottom line of sustainability)?

For the third question, the participants agreed on most of the sustainable design factors, which demonstrated that the participants are aware of the factors that should be incorporated into the design of a Saudi house. Table 5.4 illustrates the response rate in relation to the sustainability factor, descending from the highest selected factor to the lowest.

Table 5.4

Sustainability Parameters/Factors in Housing Projects

Parameters/factors	**Participants**									**Total**
	P-1	**P-2**	**P-3**	**P-4**	**P-5**	**P-6**	**P-7**	**P-8**	**P-9**	
Resources (materials)	✓		✓	✓	✓	✓		✓		6
Day light				✓		✓		✓	✓	4
Energy	✓		✓			✓	✓			4
Cost		✓	✓				✓	✓		4
Water management	✓					✓	✓			3
Recycling (water or materials)				✓	✓	✓				3
Health		✓			✓		✓			3
Natural ventilation						✓			✓	2
Quality		✓						✓		2
Total selected parameters	3	3	3	3	3	6	4	4	2	

5.2.4 Critical Success Factors and Barriers Results

The fourth question is:

What are the critical success factors and/or barriers for applying sustainability to housing in Saudi Arabia and how can barriers be managed?

The participants expressed their thoughts on the barriers and the comments from the participants on the barriers include the following:

P-1: I criticise **the LEED rating system**. I think **achieving sustainability is not to go through a list** and check whatever element is achieved. Some limitations limit the designing process of a building, which include **political, financial and social forces**. The **Saudi Government** has a big problem in **providing housing for the Saudi population**. We have **very weak designing firms that produce weak designs** and the whole design system therefore is weak. Most if not all the **Saudi investments are going in every direction** other than the housing sector. For example, the financial cities that are being built are **not directed towards providing housing for the Saudi** population, but it is founded for financial reasons. So the real question here is can the middle-class generation ranging from 21 to 30 years of age **afford to have sustainable housing**? The answer is, **they can't even afford non-sustainable housing** in order for them to afford sustainable housing. **The villa typology is not a solution** to the Saudi housing crisis. Further, the **Saudi family has changed** dramatically, socially and demographically. It has changed from being a family having six or seven children to a family having three or four. The birth rate inside the family has changed from having a baby in the first year to waiting three or four years to have a baby.

P-2: Creating **new laws** that help to **reduce the soaring property prices**, find some other privileged system for the real estate that **takes into account the needs of people** who are new house seekers, and **impose strict systems** to get buildings **distinct, healthy and at a reasonable cost**.

P-3: It seems it's a very big challenge (would be helpful) to answer to the thesis! But I think it should be divided into the following:

Policy (which include regulation and guiding systems).

Implementation (design, construction and O&M)

Type (single homes, multi-family unit and low-income)

P-4: There is **lack of understanding about the sustainability concept**. This could be managed through public demonstration of real cases with emphasis on percentage (%) savings, and through schools and university level courses or public talks and seminars. Additionally, the **availability of sustainable building materials** or **technologies is not known**. These can be managed through initiating local exhibitions and conferences about the issue. Further, **the need for affordable housing** in the local market is crucial. Managing this could be through research support and government investment in the R&D [research and development] of **developing local sustainable building materials** that could **reduce the construction cost significantly**.

P-5: Individuals or **investors** who may be concerned with factors that **are not sustainable to begin with** can suppress the growth of conventional housing. These factors become the barriers, such as: **instant profit, luxury, unsupervised house additions, building methods, and lack of knowledge**. Additionally, **willingness,** expertise **in the practice, the level of performance desired, indoor environment, and availability of raw materials** are all barriers.

P-6: **Solar energy**: Saudi Arabia is one of many countries that have the sun exposure all year around, and the housing sector is **consuming a huge amount of non-renewable energy**. For that reason, solar energy is a needed alternative to conventional energy, keeping in mind how to adapt this advanced solar energy technology in the housing sector. **Water management**: strategies to **reuse** or **treat wastewater** should be considered. **Cooling**: since Saudi Arabia has an arid climatic condition, the weather is hot most of the year. Thus, **sustainable strategies** that will help **reduce the amount of heat gain and the amount of energy** needed to cool a place should be considered.

P-7: We have not reached the stage of **preserving the environment** as other countries such as the US and the UK. There are many obstacles in the way of **saving energy** and how they should be applied to Saudi housing. One main reason for not truly applying methods of saving energy is because **energy saving** methods is far **more expensive** than conventional energy usage methods now in Saudi Arabia, so **it is easier to not save energy or use energy saving material because it is cheaper not to do so** and just use fossil fuels to generate energy. For example, when the solar panels were designed to be used in the project of the Jeddah airport, we found that the **return of investment** for such a technology will be after approximately 150 years.

P-8: First **apply the SBC**, then second **convince the stakeholders** to implement them in the construction specifications, from there it can be **conveyed to the Saudi citizen.**

P-9: Public awareness: need to educate the public on the importance of Saudi housing. Government awareness and implications: need to educate the Government sector and push for regulations.

Responses to the fourth question highlighted barriers in applying sustainable methods to housing construction in Saudi Arabia, as revealed in Table 5.5:

- high cost of sustainable housing and long period of return of investment
- lack of stakeholder interest in applying sustainable housing
- lack of public awareness of the positives of sustainable housing
- low levels of investment in sustainable housing
- shortage in sustainable construction material
- lack of alternative designs of housing and focusing only on the villa typology
- lack of awareness from designing firms of how to design sustainable housing.

Table 5.5

Barriers to Applying Sustainability to Housing

Barriers	**Participants**									**Total**
	P-1	**P-2**	**P-3**	**P-4**	**P-5**	**P-6**	**P-7**	**P-8**	**P-9**	
High cost	✓	✓	✓	✓	✓	✓	✓			7
Lack of stakeholder interest			✓		✓		✓	✓	✓	5
Lack of public awareness		✓		✓	✓			✓	✓	5
Low levels of investment	✓		✓	✓	✓		✓			5
Shortage in sustainable construction material				✓	✓	✓	✓			4
Lack of alternative designs	✓		✓			✓				3
Designing firms lack of awareness	✓		✓							2
Total barriers selected	4	2	5	4	5	3	4	2	2	

Conversely, Table 5.6 illustrates the critical success factors (CSFs) that were distilled from the comments of the participants as revealed earlier.

Table 5.6

Comparison between Participants Regarding CSFs

Critical success factors	**Participants**									**Total**
	P-1	**P-2**	**P-3**	**P-4**	**P-5**	**P-6**	**P-7**	**P-8**	**P-9**	
Implementing new laws	✓	✓	✓	✓	✓		✓	✓	✓	8
Educating firms	✓		✓	✓	✓		✓	✓	✓	7
Educating the public	✓		✓	✓	✓		✓	✓	✓	7
Environmental comfort	✓	✓	✓	✓	✓	✓	✓			7
Cost reduction	✓	✓	✓	✓	✓	✓	✓			7
Grey water treatment						✓	✓			2
Using solar energy						✓				1
Rainwater collection						✓				1
Total CSFs Selected	5	3	5	5	5	5	6	3	3	

As shown in Table 5.6 it is noticeable that the utilisation of grey water treatment, solar energy and rainwater collection are the least selected CSFs. This can be due to the high cost of installing solar panels or water treatment and collection tanks as well as the high maintenance cost of such systems as indicated by participant P-7.

5.2.5 Cultural Aspects of the SBC Results

The fifth question is:

In your opinion, does the SBC discuss or relate to the cultural needs of the Saudi population and their unique cultural characteristics?

In relation to the fifth question, which was asking the participants to discuss the SBC, it was shocking to see that six of the nine participants did not know that there was even such a building code. However, it is not surprising to find that the three participants who have had some interaction with sustainable projects have knowledge of the SBC. This was mainly due to that integration between the SBC and sustainable projects. Some of the comments from the participants include the following:

P-1: The SBC is the same as the American building code (LEED) but with some editing. The SBC does not solve the issues of sustainability. Even with the application of the building code, it will not be applied to the letter.

P-2: **I have not read** the SBC yet.

P-3: There is a SBC and it needs some work and modification to be able to meet the needs of the unique Saudi culture.

P-4: The SBC does not discuss or relate to the cultural needs of the unique Saudi population.

P-5: The SBC **misses out on fitting the Saudi lifestyle** at several stages: at the management code level; building preparation and proper definition. At the construction level: overcrowding spaces/aisles/exits … etc.

P-6: I can't speak about the SBC since **I am not very familiar with it**. However, I can tell from the built environment that **the local traditional place identity is missing**.

P-7: I have some interaction with the SBC but I found that even with it being available, **many firms and contractors don't apply it or neglect it**. There will be a great impact on the current construction sector in Saudi Arabia if the

SBC is applied, because many of the firms and contractors are **not familiar with it** and many may **lose their contractors due to lack of knowledge of it.**

P-8: There is no building code to discuss about.

P-9: I will answer this with another question: **Is there even any such building code?** I'm afraid there is not even that. I may be wrong.

Table 5.7 illustrates the response according to the knowledge of the participants of the SBC.

Table 5.7

Participants' Responses to Question 5

Knowledge of the SBC		Participants							Total
	P-1	P-2	P-3	P-4	P-5	P-6	P-7	P-8	P-9	
Yes	✓		✓		✓		✓			4
No		✓		✓		✓		✓	✓	5

5.2.6 Environmental Factors in Design Results

The sixth question is:

In your opinion, what environmental factors must be addressed in design of a Saudi house to make it sustainable?

Table 5.8 illustrates the collected response in a thematic analysis format.

Table 5.8

Participants' Responses to Question 6

Theme	Respondents									Total
	P-1	P-2	P-3	P-4	P-5	P-6	P-7	P-8	P-9	
Heat reduction/passive cooling	✓	✓		✓	✓	✓	✓	✓	✓	8
Renewable energy	✓	✓	✓	✓	✓	✓	✓			7
Energy conservation	✓	✓	✓	✓		✓	✓	✓		7
Water conservation	✓	✓	✓	✓	✓			✓	✓	7
Humidity control	✓	✓			✓	✓	✓	✓	✓	7
Day lighting	✓		✓	✓	✓		✓			5
Dust prevention				✓				✓	✓	3
Occupant health			✓		✓					2
Increase productivity			✓		✓					2
Landscaping, soil erosion		✓			✓					2
Total selected factors	6	6	6	6	8	4	5	5	4	

5.2.7 Vernacular Architecture

The seventh question is:

> What features of the vernacular architecture of Saudi Arabia would you like to see back in today's Saudi houses, or do you even agree that they should be incorporated into the design of a house, for example, the wind towers, the Mashrabiya, the inner courtyards, etc.?

Table 5.9 illustrates the collected responses according to the participant's agreement or disagreement.

Table 5.9

Participants' Responses to Question 7

Agreement	Respondents									Total
	P-1	**P-2**	**P-3**	**P-4**	**P-5**	**P-6**	**P-7**	**P-8**	**P-9**	
Agree		✓	✓	✓	✓			✓	✓	6
Disagree	✓					✓	✓			3

Some of the responses from the participants contradicted others; however, in the end they all agreed on what can be achieved if the concept behind the vernacular architecture elements was to be applied once again. The comments include the following:

P-1: **I disagree totally** to bring back vernacular architectural elements. **The past should not be incorporated into the modern**. We may **take the concept** behind the old architecture **such as passive cooling** and use it but not the same physical aspects of the vernacular architecture. There are modern similarities with traditional concepts such as passive cooling but they don't have to look like the old style at all.

P-2: **I agree strongly** to return to the use of traditional building systems because **it is the best to meet the needs of the population** in different areas, which were invented by the ancients who were having the ability to identify their needs, and it will be helpful, not costly and beautiful.

P-3: **We can definitely use the vernacular architecture** elements in modern buildings, but they have to be in a modern way.

P-4: The use of wind catchers and Mashrabiya but both in a modern form that is applicable in today's built environment.

P-5: The features of the Arab design are definite friends to sustainability and shall be revisited and embraced. In fact, they make a good entrance to spreading sustainability among the mainstream of population since they connect to the memory. However, their benefits in numbers and clear statements have been perhaps missing to people. A proof to that is that they are seen today used in a pure state of architectural decorative purposes that does not speak of the trueness of their actual job. Implementing the Arab technologies in the residential context keeps architecture environmentally friendly and spreads awareness at an individual level.

P-6: **I don't like to see a duplicate of the past**, but I encourage using the same principles and translate them in today's language.

P-7: An argument can be made on the difference between the thermal comfort zone of past generations to the thermal comfort zone of current and future generations. They are not the same, so it is not valid to say that we should not use modern technology to reach a comfortable thermal zone in our houses just as our past generations used to use passive cooling techniques. The room temperature level has changed dramatically between current generations and past generations. Past generations can be comfortable in a room temperature of 30^{o}C but current generations prefer it to be much cooler.

P-8: **I agree**, but **I don't think that we can have the same wall thickness as the old house** have which can reach to about 70 centimetres. However, if energy saving techniques are used that will resemble the past then why not.

P-9: **Wind towers, Mashrabiyas and inner courtyards can be used**, but if Mashrabiya is too expensive or for some other reason not desired, then simpler outside shutters (also wood or similar light weight material) is an option.

The respondents who disagreed to using vernacular architecture elements in current design have the same reason: the concept behind the old architecture such as passive cooling can be used but not in the same physical aspects of the vernacular architecture.

5.2.8 Privacy in Saudi House Design

The eighth question is:

> One of the crucial elements in the design of a Saudi house is it must provide privacy and be out of the sight range of passing pedestrians. In your opinion, how can we achieve privacy in a sustainable way in a Saudi house?

The question regarding the adaptation of privacy in current and future sustainable Saudi housing design had an agreement across the board, which indicates that all the participants agreed on the importance of this aspect, both culturally and religiously. Several methods of achieving privacy have been outlined by some of the panel members:

- refrain from the design constrictions of fenced villas
- employment of Mashrabiya concept
- provision of clear-story fencing along the room walls instead of typical windows
- design a house with an introverted concept (looking inside a court)
- introduce camouflage and pattern in the house, in addition to the idea of a courtyard.

The above points were summarised from the answers of the participants:

> P-1: The design of the house can achieve privacy in a sustainable way but it **does not have to be in a form of a fenced villa**. There can be other solutions to solve the problem of privacy.
>
> P-2: In my opinion, we can reconsider the design of residential neighbourhoods for new homes, which are, enjoyable, meet privacy standards

and be sustainable. To clarify that: we can **change the planning system that is entirely dependent on the network system**, which **does not have the flexibility to create open residential neighbourhoods with privacy.**

P-4: Could be through employment of Mashrabiya concept, provision of clear-story fenestration along the room walls instead of typical windows, or simply designing the houses with an introverted concept (looking inside a court).

P-5: I see the design of John Novel (Institute de Monde Arabe) as a great way of screening. The introduction of camouflage and pattern is a non-literal way of concealing and hiding something. In addition, to the idea of a courtyard where there can be internal features that can attract attention so that passage can happen behind it. The task is in the hand of designers and they can change the current 'castle' system to reach elegant and more pleasant residential typologies that belong to Saudi lifestyle and land.

P-6: The **Mashrabiya** is a good example of a sustainable strategy that **addresses privacy** issues.

P-7: I think that if any sustainable housing project is going to be constructed in Saudi Arabia, it should be in a **compound type of projects and not stand-alone projects**. Definitely **privacy is a big issue** that must be addressed in any design.

P-8: **Privacy is one of the most important things** to think about when building a house in Saudi Arabia, and not achieving it is a big red line that should not be crossed. I don't think that the Saudi family can use common areas of the house for both males and females. **Both sexes should be separated** and there is no way that this can be solved in any other way. So designing the house around this regulation in a sustainable way is OK but must not neglect it.

P-9: Perhaps **use temporary partitions** to help create private or divided spaces when necessary.

Overall, the concept of privacy can be achieved in the design process of a sustainable Saudi house, which can serve both the cultural and religious needs of its occupants. Designers should incorporate a minimum level of privacy that can fulfil the occupants' needs and any additions or alterations can be done according to the willingness of the homeowner.

5.2.9 Affordable Housing for Low- and Middle-Income Families

The ninth question is:

> How can low- and middle-income families afford houses in the current Saudi real estate market, and how differently would you like it to be (if any)?

It was not surprising to see that all the respondents agreed that no low- and middle-income families could afford a house in the current Saudi real estate market. The reasons varied:

- significant financial burden
- lack of support from the government
- public/government loan not enough
- large plots of land with high prices
- lack of incentives.

Some of the comments on this question include the following:

> P-1: In today's economic status, **no family can afford to buy a house**, and not only families; even singles should be looked after. So the real question here is can the middle class generation ranging from 21 to 30 years of age afford to have sustainable housing? The answer is they **can't even afford**

non-sustainable housing in order for them to afford sustainable housing. I might just add that the **apartments are in more demand than villas because of their affordability** compared to villas.

P-2: I think that many of the **low- and middle-income families bear the significant financial burden** for housing in Saudi Arabia, and in most cases these **homes are not responsive to their needs** (uncomfortable and not in line with the requirements of sustainability).

P-4: People can afford to buy houses mostly through mortgages and bank loans. On the other hand, the Saudi Government provides **public loans that are technically not enough** to buy neither a piece of land nor a completed/finished house in almost all major cities of Saudi Arabia. Solutions: 1) Loans with 0 APR; 2) dependency on local material; 3) building residential units with smaller land sizes.

P-5: Promotions for sustainable lifestyle and advertising via environmental agencies can promote and sponsor portions of the real estate. **Givebacks and rewards** can encourage the plan a huge deal.

P-6: The main factor that is affecting the current Saudi real estate market is the land price. Since a small portion of land is offered in the market and the demand is very high, then the prices will go high accordingly. Offering more vacant land for residential purposes will help decrease the price range and changing the density ratio.

P-7: It will be **very difficult for these families** to buy in the current market.

P-8: **No low- and middle-income family can afford to buy a house** in today's market. They all are borrowing money from somewhere to buy houses.

P-9: Most low- and middle-income people **can't afford it** and they have to take out bank loans or otherwise go into debt. Something needs to be done to make things more affordable.

5.2.10 Government Incentives/Grants for Sustainable Houses

The tenth question is:

> It is well known that the initial payment for a sustainable house is higher than a normal house. How can low- and middle-income families afford to pay for sustainable houses, and can the Government intervene in making it more affordable (i.e., incentives, grants)?

The following detailed answers from the participants show how disapproving they are of the current expensive rate of the Saudi real estate market:

> P-1: Sustainable rating systems should not make sustainable houses more expensive than non-sustainable houses. I really criticise this approach from such sustainable rating systems. I think it's illogical to ask for more money in order to save money. The middle-income family that has no outside financial aid to help with buying a house and needs 30 years at least to cover the expenses of buying a house in the current Saudi real estate market. The government real estate loan programme is not a solution and will not fulfil the needs of the Saudi population. Because it takes a very long time to get it and the amount does not cover the price of the land and the construction of the house together. Some other means of borrowing needs to occur, otherwise the house will not be built with the current land prices and construction costs.

> P-2: Nowadays, middle- and low-income families are relying on loans from banks, which constitute a significant burden, but I think that the Government can intervene to reduce the high prices of the property, and to charge for the land monopoly by real estate dealers.

> P-3: Green building concepts can be implemented as an option by owners who are seeking incentives presented by local municipality. Consultants are encouraged to present the advantages of green building technology to clients. Only large projects should be regulated by the authority because it impacts on the community and the city infrastructure.

P-4: ‘First, the people have to fully appreciate the concept of a sustainable housing and how the long-term benefits are to their side, besides the environmental advantages. It might take quite a longer time to see low- and middle-income families move towards sustainable housing especially that the energy prices are still reasonable and the main concern when it comes to the energy bills is to lower the consumption by mainly one factor that is insulation. Second, after people have appreciated the concept, then the Government has to initiate many incentives or grants to encourage people to build with a sustainable approach.

P-5: **Intensives and grants can sure be given**; however, the Arab and Saudi heritage has already enough in the social bank that one can think it is time for a little reward. For instance, family houses are a sustainable idea to begin with. Farms, safety, family education level, safe drivers … all these social criteria belong to sustaining a society and a home. The Government shall look into that and this should be a unique trait that will distinguish a conservative society in a good way.

P-6: **Offering grants** for applying sustainable strategies can **encourage residents** to accommodate them in their houses. For example, some countries have the **tax exemption policy** to encourage the public implementing sustainable development.

P-7: I have noticed that there is a trend from some of the Saudi Government bodies to react towards saving and preserving the environment. One main government body that is very keen on applying regulations to save and preserve the environment is the council of meteorology and environment protection. So in my opinion as long as we have touched on issue regarding saving and preserving the environment, then I think we can go forward and apply the concepts of sustainability.

P-8: They can’t on their own, but if the Government intervenes then that might be possible.

P-9: The Government should intervene—offer programmes similar to grants as incentive for those who will purchase sustainable housing. Also, need to educate all on how future maintenance as well as electric bills will be lowered with sustainable housing, so that making the initial investment is worth the extra initial cost.

The following points summarise the participants' responses. The Saudi Government must:

- reduce the price of land
- increase the public/government loan
- establish a national authority that regulates the application of sustainability
- introduce incentive schemes or grants
- educate the public on the benefits of applying sustainability measures such as energy conservation
- lead by example and apply sustainability to its buildings.

5.3 DISCUSSION

The high cost of living has discouraged people to implement a sustainable housing concept. The public perception about this 'concept' is expensive, and some of the public is still not aware about the 'concept'. With the large estimated population in Saudi Arabia, it is no easy task to apply a sustainable housing concept to a country that has developed from living in tents in the 1930s and convince them that this the right way. The findings from the interview suggest accommodating the conservative Saudi culture in design requirements for sustainable houses. The main aim of conducting the semi-structured interview was to formulate the questions for the Delphi rounds. The following points are derived from the interview:

- enlighten architectural and construction firms on sustainable designs
- implement regulations resulting in enforcement of application of sustainable methods in housing construction
- encourage the Saudi Government to erect affordable sustainable housing units
- promote green energy to become the main energy source for housing
- promote the importance of rainwater collection
- promote the value of grey water treatment systems.

This discussion of the applicability of sustainable methods on the housing construction industry in Saudi Arabia can be utilised for other developing countries in the region that are faced with similar housing shortage especially for mid and low-income families.

5.4 SUMMARY

The semi-structured interviews were considered a pilot study to formulate the questions for the first Delphi round. The results from the two Delphi rounds will now be examined (the questions that formulated from this semi-structured interview). The two Delphi rounds had 10 sections with an additional eleventh section regarding the demographic information of the participants. The 10 sections comprised 95 questions, distributed among the 10 sections according to their relevance. The two Delphi rounds provide great insight and are strongly related and connected to the research questions and objectives—the details of which will be examined more closely in the next chapter.

Chapter 6: Delphi Rounds Results

6.1 INTRODUCTION

The Delphi method utilised in this thesis is the core research method that answers the research questions and achieves the research objectives. The responses to each survey were returned to the researcher, who summarised them and reported to each panel member all of the opinions expressed by the panel. These reports were anonymous so that the pitfalls of ego, domineering personalities and the ‘bandwagon or halo effect’ in developing consensus were avoided. Table 6.1 shows the profile of the participants. There were 38 that agreed to fill in their profile information, while nine skipped this question in the survey. Figure 6.1 shows the type of organisation panel members’ types of employment organisations.

Table 6.1

Delphi Rounds Participant Profiles

Participant	Years of experience	Profession
1	1	Research assistant
2	43	Executive manager
3	21	Assistant professor
4	1	Architect
5	3	Architect
6	2	Landscape architect and environmental consultant
7	7	Project architect/PhD candidate in science of design
8	8	Founder and lead architect
9	6	TA
10	27	N/A
11	26	General manager

Participant	Years of experience	Profession
12	3	Project coordinator—urban planning engineer
13	29	Strategic studies
14	20	Director—Centre for Sustainability and Green Building
15	5	Architectural engineer
16	5	Architectural engineer
17	3	Architect
18	3	Architect
19	3	Architect
20	27	Architecture Department director
21	4	Architect/project manager
22	6	Mega Project Department engineer
23	15	Lecturer
24	30	Chairman, CEO
25	12	Assistant professor
26	35	CEO
27	12	Assistant professor and chairman, Architecture Department
28	20	RAND director
29	3	Designer, coordinator
30	3	Sustainability engineer
31	25	Executive director for southern region
32	29	Chief consultant
33	10	Project technical support manager
34	9	Architectural engineer and manager of the Department of Studies
35	10	Architectural engineer
36	24	Quality administration manager
37	8	Business development manager
38	12	Design and engineering manager

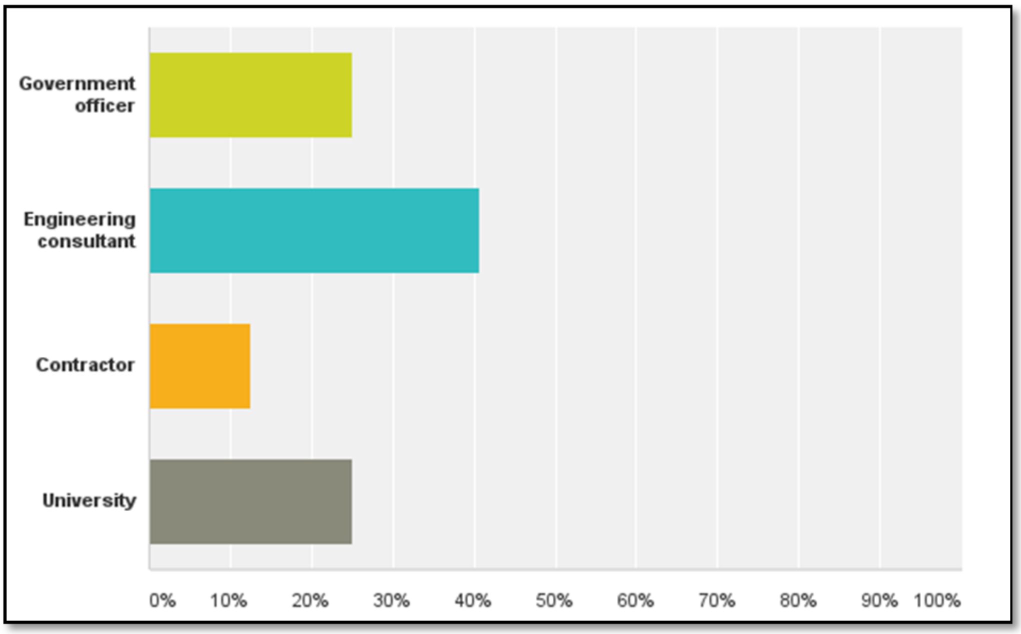

Figure 6.1. Panel members' type of organisation.

6.2 DELPHI ROUND 1 FINDINGS AND DISCUSSION

The findings from the first Delphi round have been categorised according to the subject or theme of the questions posed to the participants. The survey was divided into 10 sections:

1. Definition
2. Sustainability Factors
3. Barriers
4. Enablers
5. SBC
6. Saudi Government
7. Environmental Factors
8. Saudi Culture
9. Privacy in Saudi culture
10. Affordability.

An eleventh section was for the participants to write their personal demographic information, such as name, years of experience and job position. Each section had a set of questions that were derived from the semi-structured interview. A total of 95 questions were asked of the participants in the first round. Each of the survey sections will be discussed and the results shown as follows.

6.2.1 Definition

This was the first section of the first Delphi round. The aim was to get a general sense of the participant's knowledge on the subject and obtain consensus on the sustainability elements derived from the definition of sustainability. The question was:

> It is well known that the main factor behind the development of sustainability is to make sure that natural resources are not jeopardised for future generations. Several factors go into the definition of sustainability, which includes environmental factors, economic factors and social factors; the three factors formulate the sustainability triangle.

The responses are displayed in Table 6.2, which represents the total ratings from all the participating stakeholders. The table has been organised according to the mean, mode and median that was used to provide the rating of each indicator, while the standard deviation (SD) was used to examine the uniformity/convergence of each indicator. For round 1, the indicators were categorised based upon the mean cut-off score. The indicator was rated high if the mean score was equal to or higher than 5. The indicator was rated medium if the mean was equal to 4 and less than 5, while the indicator was rated low if the mean was below 4.

Table 6.2

Responses to the Definition Question in Round 1

	Median	Mean	Mode	Standard Deviation	Variance	Min	Max	Rank
Environmentally friendly	5	5	5	0.91	0.83	3	6	High
Has low-cost long-term maintenance	5	5	6	1	1	2	6	
Energy efficient	5	5.2	6	1.22	1.5	1	6	
Employing (absorbing) the local weather	5	5.08	6	1.1	1.16	2	6	
Suitable for the local environment and cultures	5	4.72	5	1.06	1.13	2	6	Medium
Built from local materials	5	4.46	5	1.04	1.07	3	6	
Affordable to the consumer	5	4.24	5	1.33	1.77	2	6	

As shown in Table 6.1, the following sustainability elements derived from the definition of sustainability were ranked as high according to the responses' mean cut-off score:

- environmentally friendly
- low-cost, long-term maintenance
- energy efficiency
- employing (absorbing) the local weather.

One of the comments from the participants regarding the importance of behavioural change was:

> One important factor is the behavioural factor that has to do with how people behave towards certain measures, such as the use of electricity unnecessarily or for heavy entertainment and unproductive

things, or accepting natural lighting as the main source of interior lighting when there is not enough of it. Sometimes the behaviour of people greatly affects the outcome of a sustainability exercise regardless of how well you have achieved your sustainable goals in the design and implementation of the housing units.

In analysing the factors that should be incorporated into all phases of any housing construction project in Saudi Arabia, all three pillars of sustainability must be interconnected to achieve the optimum outcome. As shown in Table 6.1, the highest ranked factor was ‘environmentally friendly’. The participants ranked this factor to be high according to the mean value (5) but had a SD of less than 1. Conversely, the lowest mean value according to the ranking of the participating stakeholders was the ‘Affordable to the consumer’ factor, with a mean value of 4.24 and a SD of 1.33. Figure 6.2 illustrates the distributed level of agreement between participated stakeholders that ‘Affordable to the consumer’ is the lowest ranked factor in applying sustainability to housing construction in Saudi Arabia, according to the mean value.

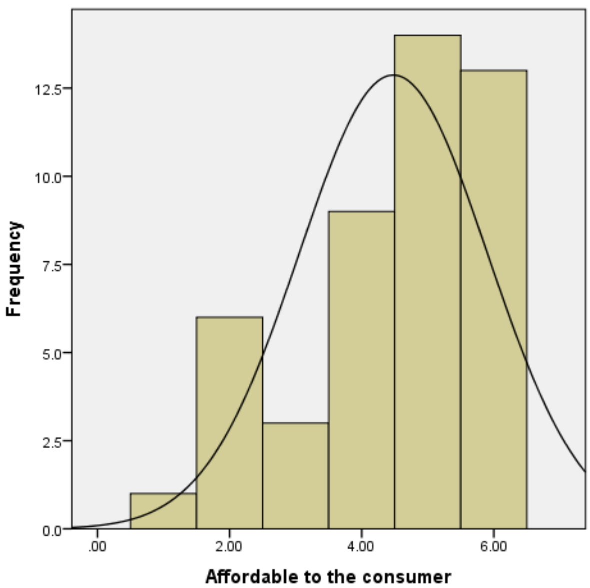

Figure 6.2. Lowest ranked element in the definition question.

6.2.2 Sustainability Factors

After obtaining the responses to the first question on general knowledge of the definition of sustainability, the second section sought more detailed factors on sustainability. Table 6.3 shows the sustainability factors and responses to the following question:

> The importance of sustainability is that it should be implemented in the early stages of the project, starting from the feasibility stage, and should implement several factors. Please select the appropriate level of agreement to the following elements.

Table 6.3

Responses to the Sustainability Factors Question in Round 1

	Median	Mean	Mode	Standard Deviation	Variance	Min	Max	Rank
Natural Lighting	6	5.48	6	0.77	0.59	3	6	High
Water Conservation	6	5.4	6	1	1	2	6	
Natural Ventilation	6	5.36	6	0.86	0.74	3	6	
Thermal Comfort	5	5.32	6	0.85	0.73	3	6	
Site Orientation	5	5.24	6	0.83	0.69	3	6	
Optimum use of Local material	5	5	5	0.82	0.66	3	6	
Thermal Insulation	5	5.24	6	1.01	1.02	2	6	
Indoor Air Quality	5	5.16	6	1.07	1.14	2	6	
Passive Cooling (Less use of mechanical cooling)	5	5.04	6	1.17	1.37	2	6	
Structural Quality	5	5	5	1.12	1.25	2	6	
Use of Green Energy	5	4.92	5	1.22	1.49	2	6	Medium
Recycling Material (Waste)	5	4.92	6	1.07	1.16	2	6	
Accessibility (Near all amenities)	5	4.92	5	1.04	1.07	2	6	
Grey/Rain Water Treatment	5	4.8	6	1.41	2	1	6	
Physical Health (Well-being)	5	4.8	5	1.35	1.83	1	6	
Low Maintenance Cost	5	4.72	5	1.24	1.54	2	6	
Mental Health	5	4.64	6	1.44	2.07	1	6	
Low Initial Cost	3	3.72	3	1.37	1.88	2	6	Low
High Maintenance Cost	2	2.68	2	1.44	2.06	1	6	
High Initial Cost	4	3.56	4	1.5	2.26	1	6	

As shown in Table 6.3, the following sustainability factors were ranked as high according to the responses' mean cut-off score:

- natural lighting
- water conservation
- natural ventilation
- thermal comfort
- site orientation
- optimum use of local material
- thermal insulation
- indoor air quality
- passive cooling (less use of mechanical cooling)
- structural quality.

In addition to the above factors, an optional question was asked: 'What materials can be used that are sustainable in the Saudi construction market? (Please Discuss)'. Some of the participants provided their answers, which are:

- adobe
- palm tree leaves
- stone
- treated concrete
- green concrete
- recycled ceramic
- clay

- wood.

A useful comment from one of the participants regarding the use of local sustainable construction material was:

> Earth as a construction material is the most sustainable material for housing, not only in Saudi Arabia but in most of the world. It used to be the only building material in Saudi Arabia for a long time, until the oil wealth changed the way Saudis design and construct their houses. All regions of Saudi Arabia were using earth as the main material, whether it was mud reinforced with straws (like in the Central, Northern, and Eastern regions) or stones (like in the Western and Southern regions). The current new building technique with earth can make the house look very modern. The problem is with the designers and acceptance from people, as there still exists a mental barrier to going back to earth as a very sustainable and affordable solution for our environment. It is also very advanced in thermal comfort and heat/cold insulation. The points that I disagree with above are very true if we are going to use earth and local building material. One can fit a house with all technologies and imported materials to make it green and sustainable, but the question is: will that be long time in terms of maintainability and durability, with a low running cost? If not, then this negates the core principle of standard deviation in the first place.

As shown in Table 6.3, the highest ranked sustainability factor was 'natural lighting'. The participants ranked this factor to be high according to the mean value, which is 5.48, with a SD value of 0.77. The lowest mean value according to the ranking of the participating stakeholders was 'high initial cost', with a mean value of 3.56 and a SD value of 1.5. Figure 6.3 illustrates the high level of disagreement between participating stakeholders on 'high initial cost'.

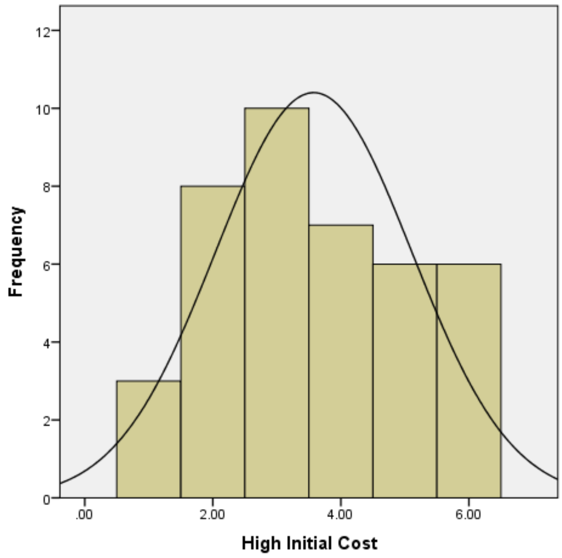

Figure 6.3. Distributed responses to the lowest ranked element in the sustainability factors question.

6.2.3 Barriers

The barriers section was a crucial component in the survey because it was one of the main motivations for undertaking this thesis. Table 6.4 shows the responses of the participants to the following question:

> The following statements are considered barriers to applying sustainability to housing in Saudi Arabia according to the literature. Please select the appropriate level of agreement to the following elements:

1. Lack of public awareness of the benefits of sustainable housing
2. Lack of key stakeholders' interest in applying sustainable housing
3. Shortage of sustainable construction materials
4. High initial cost of sustainable housing
5. Long period of return of investment (payback period)
6. Low levels of investment in sustainable housing
7. Lack of alternative designs of housing

8. Lack of awareness from designing firms of how to design viable sustainable housing
9. Lack of government support (guidelines, building codes)
10. Lack of financial incentives (subsidies, insurance discounts, bank loans, etc.).

Table 6.4.

Responses to the Barriers Question in Round 1

	Mode	Mean	Median	Standard Deviation	Variance	Min	Max	Rank
Public awareness	6	5.12	5	1.05	1.11	2	6	High
Stakeholders' interest	5	4.96	5	0.99	0.97	2	6	Medium
Low levels of investment	6	4.72	5	1.37	1.88	1	6	
Financial incentives	5	4.44	5	1.56	2.42	1	6	
Design firms awareness	5	4.44	5	1.56	2.42	1	6	
Government Support	6	4.44	5	1.56	2.42	1	6	
High initial cost	5	4.28	5	1.46	2.13	2	6	
Alternative designs	5	4.08	4	1.41	2	1	6	
Sustainable construction materials	3	3.88	4	1.54	2.36	1	6	Low
Long period of ROI	4	3.8	4	1.32	1.75	1	6	

The participants gave comments on the barriers as follows:

Education, education, education ... In universities, schools and local media is a good way to start awareness!

Standards, guidelines and regulations are not in place.

The cost is the main factor and nothing else. If sustainable methods improve and become comparable to everyday costs, everybody would choose sustainability. The Government must give incentives and requirements.

For government departments, the direction towards sustainability is there, but there is a lack of motivation, comprehension, and the resources are weak.

As shown in Table 6.4, the following barrier was ranked as high according to the responses' mean cut-off score: 'Lack of public awareness of the benefits of sustainable housing.' This can be seen as a major barrier because if the public is unaware of the benefits of sustainable housing, then no residents will be willing to integrate sustainability into their home. This high-rated barrier is a reinforcement of Salama's (2007) assertion that this barrier will be the main obstacle in the way of developing the country in general and sustainable housing specifically. Additionally, public unawareness of the benefits and potential of smart technologies to achieve sustainability is another hurdle to sustainable housing construction. Public participation is a result of public awareness and, as Davy (2006) stated earlier, some of the benefits of public participation in any development include economic growth, social equity and ecological integrity.

Barriers 2, 6, 10, 8, 9, 4 and 7 were rated as being of medium value respectively. These seven barriers have some commonality between them: they are all concentrated around stakeholders' and government involvement, with a financial barrier linked to them. Collaboration between all stakeholders is essential for any industry to flourish and be prosperous. Mathur et al. (2008) stated that new types of authority and decision-making procedures that involve a wide range of stakeholders are the requirements to achieve sustainability. Stakeholder involvement in urban development projects in any country need to come together to achieve a common goal based on agreed priorities, polling resources and maximizing comparative advantage (Mandeli, 2008). In addition, Ferroukhi and Ghazal-Aswad (2013) have also stated 'the lack of political support, the lack of incentives to encourage private sector participation, as well as the lack of awareness of appropriate stakeholders of the opportunities available' (p. 102). Their statement reinforces the majority of the above-mentioned barriers, which are related to lack of government support and lack of stakeholder involvement.

Two barriers—3 (Shortage in sustainable construction material) and 5 (Long period of return of investment [payback period])—are considered low value. Barrier 3 has scored a low rating mainly because participants believe that it is not true to some point. According to feedback from the participants, there is sustainable construction material available in the Saudi construction market. The question that should be asked is whether it is too expensive for the average Saudi resident to purchase and incorporate into the construction of their house.

There are sustainable construction materials in the housing construction market across Saudi Arabia and throughout the GCC housing construction market, but the problem again is the lack of knowledge of such construction materials. There were several attempts by the Saudi Government to help in achieving sustainability through the conservation of natural resources such as water and reducing and rationalising electricity usage. In 2008, the Custodian of the Two Holy Mosques, King Abdullah bin Abdul-Aziz, 'marked the beginning of the Electricity Rationalization Campaign by highlighting the Kingdom's investment in services and infrastructure and the need for responsible use of resources' (Al Maimouni, 2008). In 2010, the Saudi Government established the new SEEC for energy conservation goals. However, according to Nambiar (2012. p. 2), 'it was only in 2012 that the centre was catapulted into the limelight with plans to establish an energy label database in cooperation with other bodies in addition to a hands-on training program on energy auditing and the establishment of a qualification program for energy efficiency practitioners'. People need to know the importance of using these sustainable materials because they serve to preserve resources for future generations. Osman and Montasser (2003. p. 10) accentuate the importance of preserving resources for future generations: 'When wealth is derived from a non-renewable resource, such as oil, its income becomes a Ricardian rent. In this case, the macroeconomic theory approach prescribes the need to determine what constitutes a sustainable level of government consumption to preserve resources for future generations'.

6.2.4 Enablers

Enablers was the second most important component that required answers. Table 6.5 shows the responses of the participants to the following question:

> The following statements are considered enablers to applying sustainability to housing in Saudi Arabia according to the literature, if the Saudi Government establishes a minimal sustainable housing standard to be applied to housing projects. Please select the appropriate level of agreement to the following elements:

1. Educating firms on how to design sustainable housing
2. Enlightening the public on the advantages of sustainable housing
3. Implementing new laws that enforce the utilisation of sustainable methods to housing construction
4. Applying sustainable construction methods that meet the environmental comfort needs of residents
5. The provision by Saudi Government agencies of affordable sustainable housing units for low-income families
6. Green energy should be the main energy source of sustainable housing in Saudi Arabia, such as solar energy

7. Enforcing rainwater collection and grey water treatment systems on every housing project, new or old
8. Residents in any Saudi neighbourhood should have all basic needs within walking distance such as a mosque, a shopping centre and access to government offices
9. The Saudi Government should provide financial incentives (subsidies) to whoever applies sustainable construction methods to their house.

Table 6.5

Responses to the Enablers Question in Round 1

	Mode	Mean	Median	Standard Deviation	Variance	Min	Max	Rank
Public Awareness	5	5.28	5	0.74	0.54	3	6	High
Comfort needs	5	5.24	5	0.72	0.52	3	6	
Educating firms	5	5.08	5	0.86	0.74	2	6	
Provide financial incentives	6	5.32	6	1.31	1.73	1	6	
Implementing new laws	6	5.16	5	1.18	1.39	1	6	
Providing affordable sustainable housing	5	4.96	5	1.27	1.62	1	6	Medium
Use of Green energy	5	4.88	5	1.3	1.69	1	6	
Rainwater collection and Grey water treatment	5	4.76	5	1.27	1.61	1	6	
All basic needs within walking distance	6	4.76	5	1.54	2.36	1	6	

As shown in Table 6.5, the following enablers were ranked as high according to the responses' mean cut-off score:

- educating the public on the advantages of sustainable housing

- applying sustainable construction methods that meet the environmental comfort needs of residents
- educating firms on how to design sustainable housing
- the Saudi Government should provide financial incentives (subsidies) to whoever applies sustainable construction methods to their house
- implementing new laws that enforce the utilisation of sustainable methods to housing construction.

The participants commented on the enablers (CSFs) as follows:

> Municipalities should have laws that force owners to apply energy efficient systems in projects that consume more than a certain level of energy to save energy for future generations.
>
> The point regarding green energy can be further broken down into two categories because there are mainly two types of green energy resources that could be used to supply electricity to homes: 1) On-site green energy sources, 2) Off-site green energy sources, which should be clearly distinguished. On-site is an energy generation technology (solar, wind, etc.) that is within the property of the owner, while off-site is usually coming from the grid, which is the Government's responsibility to provide in Saudi Arabia. Many green homes in advanced countries around the world have a dual metering system if they have on-site energy generation system such as solar panels, meaning when there is a surplus in energy supply from the on-site system, the meter will allow the excess to go back to the grid, which will appear later in the energy bill as a deduction for the owner.
>
> The issue of walking distance in KSA is crucial. It is a good point to look into by taking into consideration public spaces (public transportation might also be interesting).

> I agree with all of the above, and although sustainability awareness could be present in the minds of the upcoming generation, it is still not quite there at an investment level in the construction and architecture domain particularly.

In the enablers' analysis, all participants agreed that it is important to increase public awareness of the benefits of sustainable housing and to educate the key stakeholders in designing sustainable housing that utilises smart technology. Government involvement and support is considered important, which includes, but is not limited to, implementing laws that can enforce sustainable housing development, providing financial incentives, and providing affordable sustainable housing. Implementation of sustainable construction methods as well as smart technologies such as appropriate water preservation and waste water treatment systems are also considered important for successfully implementing sustainability into the housing development projects. To show how much is needed to establish solar radiation farms, Ferroukhi and Ghazal-Aswad (2013. p. 88) state: 'GCC countries have a high-potential in solar radiation (Saudi Arabia having the highest one), which would allow them to generate energy at relatively high efficiency. Only 0.2 per cent of GCC land area (625,000 km^2) of GCC countries (2.5 million km^2) is needed to fulfil all the electricity needs of GCC citizens'. Saudi Arabia has another renewable energy source, which is wind power generation. According to Ferroukhi and Ghazal-Aswad (2013. p. 89), 'Saudi Arabia comes first with 1789 h and UAE comes last with 1176 h. According to the RES, countries with more than 1,400h per year are considered to have economically viable wind energy utility'.

6.2.5 The Saudi Building Code

The following question was posed to the participants in the first Delphi round regarding the role of the SBC:

> The SBC is a set of rules and regulations that designers, contractors and all construction stakeholders should/must refer to and it was approved and published in 2007. Please select the appropriate level of agreement to the following elements:

1. All designing firms should have a good understanding of the SBC
2. New housing projects must use the SBC at least to the minimum standards
3. I have heard of the SBC
4. Increase public awareness of the SBC, e.g., through local media.
5. Existing houses need to be renovated to reach the minimum level required by the SBC
6. Saudi architectural designing firms do not use the SBC
7. I have extensive knowledge of the SBC
8. I use the SBC constantly
9. The Saudi public has knowledge about the SBC
10. The SBC is new to me and I have not used it or had any experience with it
11. This is the first time I have heard of the SBC
12. The SBC discusses or relates to the cultural needs of the Saudi population and their unique cultural characteristics
13. Design firms stick to and follow the SBC.

The responses are displayed in Table 6.6.

Table 6.6

Responses to the SBC Question in Round 1

	Median	Mean	Mode	Standard Deviation	Variance	Min	Max	Rank
Design firms awareness	6	5.44	6	0.77	0.59	3	6	High
New housing projects must use SBC	5	5.08	5	1.04	1.08	1	6	
heard of the SBC	5	4.96	6	1.24	1.54	2	6	Medium
Increase public awareness	5	4.92	5	1.08	1.16	2	6	
Renovate existing houses to comply with SBC	5	4.36	5	1.38	1.91	1	6	
Design firms don't use the SBC	4	3.68	4	1.11	1.23	1	6	Low
Have extensive knowledge of the SBC	3	3.32	2	1.34	1.89	1	6	
Use the SBC constantly	3	2.76	2	1.33	1.77	1	5	
Saudi Public knowledge on SBC	2	2.52	2	1.36	1.84	1	6	
SBC is new and have not used it	2	2.48	2	1.45	2.09	1	6	
First time to hear of the SBC	1	1.88	1	1.3	1.69	1	5	

The following elements of the SBC section were ranked as high according to the responses' mean cut-off score:

- all designing firms should have a good understanding of the SBC

- new housing projects must use the SBC at least to the minimum standards.

Some of the comments from the participants included the following:

> I believe new projects should go beyond the existing SBC.
>
> The SBC should only be applied if it’s following the international standards.
>
> In one of the projects I had designed at work, I was almost forced to go against the code, and by my own boss. When the engineering office had marked my drawings in order to give me the new guidelines to maintain in my revised set of documents, they were treated as a standard and unpleasant.
>
> There are some companies and firms who use the SBC but they are few.
>
> The public knows the SBC by name only.

In analysing the role of the SBC in the housing construction industry in Saudi Arabia, there is a difference in responses to different elements as can be seen in Table 6.6. The highest ranked element was ‘All designing firms should have a good understanding of the SBC’ with a mean value of 5.44 and SD value of less than 1. The level of agreement on this element is very encouraging, indicating the need to address the stakeholders in the Saudi Government to make the SBC mandatory and applied to all current and future housing construction projects. This research recommends that the MOMRA as the governing body of the application of the SBC in collaboration with the Ministry of Housing and Public Works (MOHPW) should mandate the use of the SBC in all construction projects, especially housing projects. This is because housing construction projects are on the rise both in price and in demand (Naffee, 2013).

The lowest ranked element is ‘This is the first time I have heard of the SBC’ with a mean value of 1.88. The level of disagreement on this question means that there is a large gap between those who have heard about the SBC and those who do not know of it. Figure 6.4 demonstrates the high peak of disagreement, which means that the majority of participants have heard of the SBC but vary in the level of involvement in using the SBC. This can mean that the sheer newness of the SBC can have a great influence on the level of involvement of key stakeholders. Since it is not mandatory to utilise the SBC yet, this level of involvement will not change to the desired level of all stakeholders being involved and applying the SBC. Even though the KSA is trying to build smart and sustainable buildings and ‘has announced its intention to spend SR 150 billion (US$39.9 billion) over a period of eight years beginning 2010 for the construction of “smart buildings” across the kingdom’ (Ventures Middle East, 2011. p. 11), the SBC is yet to be applied on all construction projects, especially housing, where it can be seen and assessed in the near future.

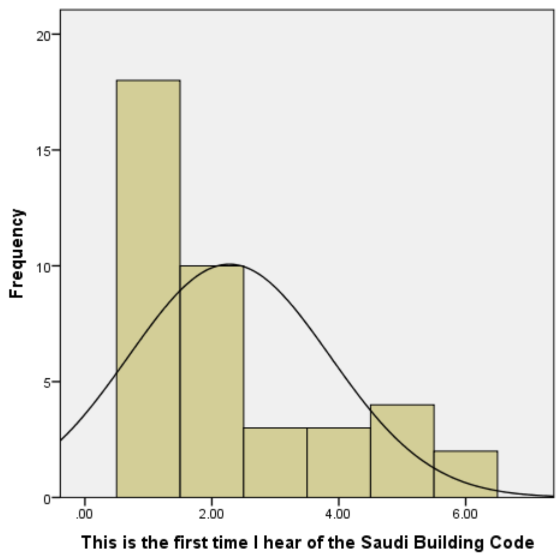

Figure 6.4. High level of disagreement on one of the elements from the SBC question.

6.2.6 Saudi Government

The following question was posed to the participants in the first Delphi round regarding the role of the Saudi Government:

> The Saudi Government, through several ministries and local municipalities, has great influence on the housing construction in Saudi Arabia. This section will get the panel's perception on the role of the Saudi Government in the housing construction industry in Saudi Arabia. Please select the appropriate level of agreement to the following questions:

1. How extensively does the Saudi Government intervene in the design and construction of houses in Saudi Arabia?
2. How would 'change' in the ideas of the Saudi population regarding the application of sustainable methods on housing be acknowledged by the Saudi Government and other official bodies in Saudi Arabia?

   The responses are displayed in Table 6.7 below.

Table 6.7

Responses to the Saudi Government Question in Round 1

	Median	Mean	Mode	Standard Deviation	Variance	Min	Max	Rank
Saudi government involvement	3	3.63	2	1.44	2.07	2	6	Low
"Change" acknowledged by the Saudi government	4	3.42	4	1.32	1.73	1	6	

Overall, all the elements were ranked low because the mean was lower than 4. The responses from the participants were not surprising. The first question had the largest variance when compared to the second. It also had the largest SD. To illustrate the level of disagreement, Figure 6.5 is a histogram that shows a bell curve peaking towards disagreement, which happens to be on the left portion of the graph.

Of the participants, 52 per cent disagreed that the Saudi Government intervenes in the design and construction of houses in Saudi Arabia. This can be seen as a major setback in the progress of the development and application of sustainable housing construction. As Mathur et al. (2008. p. 602) stated, ‘sustainability is an ambitious goal which requires, among other efforts, new kinds of governance and decision-making processes involving a large variety of stakeholders’.

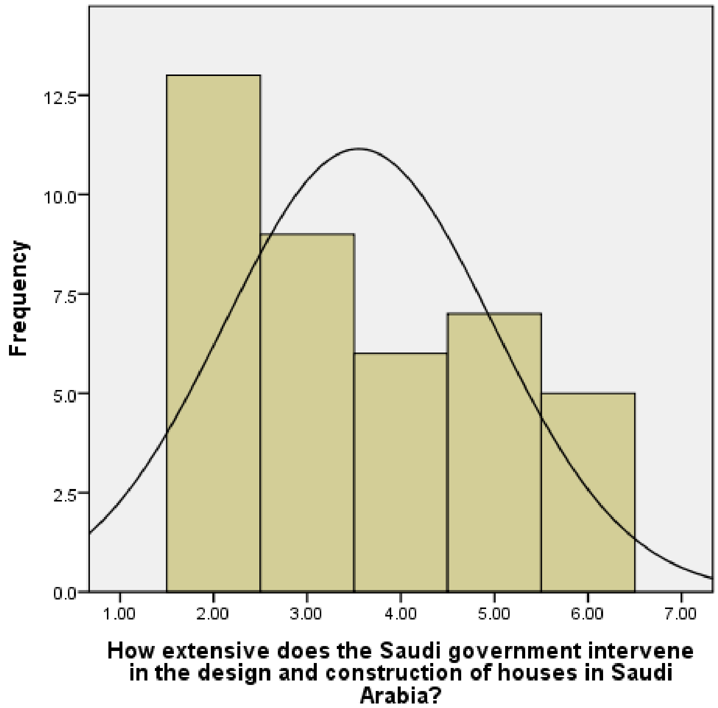

Figure 6.5. Level of disagreement with the third element in the Saudi Government question.

In total, all the elements were ranked low, leading to the conclusion that there is a lack of involvement or intervention from the Saudi Government when it comes to the housing construction industry in Saudi Arabia, especially in sustainable housing construction. However, to overcome this level of disagreement, this thesis encourages all Saudi housing construction stakeholders to be involved for the development of all projects. A better outcome is possible when all come together to achieve a common goal, which is to achieve sustainability. Since constructing green and sustainable buildings is 2 to 13 per cent more costly than constructing traditional buildings (CA News Network, 2013b), the Saudi Government's role can be to minimise what it can of the overall cost of constructing green and sustainable buildings.

6.2.7 Environmental Factors

The following question was posed to the participants in the first Delphi round regarding the role of environmental factors:

> Several environmental factors must be addressed in the design of a Saudi house to make it sustainable. Please select the appropriate level of agreement to the following elements:

3. Passive cooling
4. Privacy
5. Energy saving
6. Cost saving
7. Water insulation (interior insulation)
8. Water conservation
9. Thermal insulation
10. Thermal comfort
11. Landscape
12. Site orientation.

The responses are displayed in Table 6.8.

Table 6.8

Responses to the Environmental Factors Question in Round 1

	Median	Mean	Mode	Standard Deviation	Variance	Min	Max	Rank
Energy Saving	6	5.56	6	0.58	0.34	4	6	High
Thermal comfort	5	5.4	6	0.65	0.42	4	6	
Thermal Insulation	6	5.44	6	0.82	0.67	3	6	
Cost Saving	5	5.24	6	0.97	0.94	2	6	
Water Conservation	5	5.2	6	0.96	0.92	2	6	
Site orientation	5	5.16	6	0.99	0.97	3	6	
Passive Cooling	5	5.12	5	0.83	0.69	3	6	
Landscape	5	4.96	5	1.02	1.04	2	6	Medium
Privacy	5	4.8	6	1.32	1.75	1	6	
Water insulation (Interior insulation)	5	4.76	5	1.05	1.11	2	6	

The following elements of the environmental factors section were ranked as high, according to the responses' mean cut-off score:

- energy saving
- thermal comfort
- thermal insulation
- cost saving
- water conservation
- site orientation
- passive cooling.

Figure 6.6 illustrates the lowest ranked environmental factor, which is water insulation (interior insulation), and shows that participants had different responses peaking towards agreement.

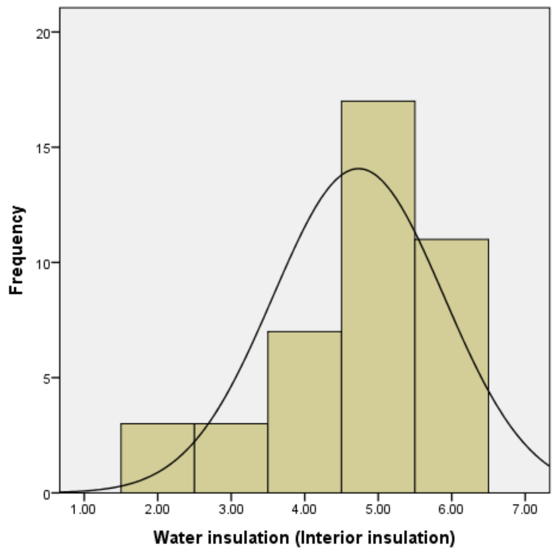

Figure 6.6. Lowest-ranked environmental element—water insulation (interior insulation).

6.2.8 Saudi Culture

The following question was posed to the participants in the first Delphi round regarding the role of the Saudi culture:

> Many architectural features and elements have defined the Saudi culture and have proved to serve the unique conservative Islamic culture of the country. Please select the appropriate level of agreement to the following elements:

1. Vernacular architectural elements should be incorporated in today's housing design
2. Mashrabiyas can be designed in an efficient and modern way and can be incorporated into the design of a Saudi house.

3. Passive cooling can be achieved utilising the techniques behind vernacular elements such as wind towers
4. Courtyards can be used to ventilate the house as well as provide natural lighting to adjacent rooms
5. The traditional courtyard was not just an architectural element. It had social impacts as well. For example, it was a gathering place for the whole family
6. Saudi Arabia's unique Islamic culture is not reflected in many designs of modern houses.

The responses are displayed in Table 6.9.

Table 6.9

Responses to the Saudi Culture Question in Round 1

	Median	Mean	Mode	Standard Deviation	Variance	Min	Max	Rank
Courtyard design incorporation	6	5.28	6	0.84	0.71	4	6	High
Social benefit of courtyards	5	5.16	5	0.9	0.81	2	6	
Passive cooling from Vernacular Architecture	5	4.92	5	0.91	0.83	2	6	Medium
Using Mashrabiya	5	4.68	5	0.95	0.89	3	6	
Saudi Arabia's unique Islamic culture	5	4.64	6	1.38	1.91	1	6	
Incorporating Vernacular architectural elements	4	4.24	4	1.13	1.27	2	6	

The following elements of the Saudi culture section were ranked as high, according to the responses' mean cut-off score:

- Courtyards can be used to ventilate the house as well as provide natural lighting to adjacent rooms

- The traditional courtyard was not just an architectural element. It had social impacts as well. For example, it was a gathering place for the whole family.

Figure 6.7 illustrates the lowest ranked Saudi culture factor, which is that vernacular architectural elements should be incorporated in today's housing design. It illustrates that the participants varied in their responses but it can generally be argued that they agree.

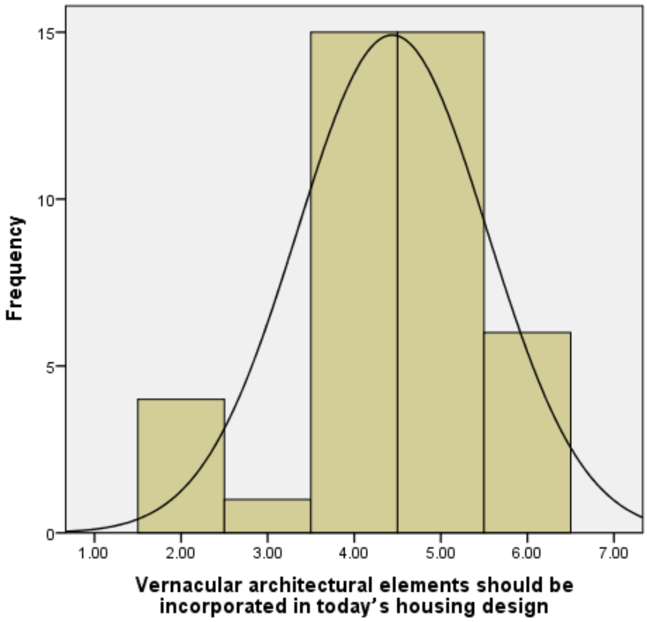

Figure 6.7. Lowest ranked Saudi culture factor—the use of vernacular architectural elements.

Some participants gave the following comments:

> One of the features that can be taken into consideration is the openings in vernacular architecture and their benefits in passive energy (depth, size, etc.).

> This issue can extend to the planning elements of the neighbourhood to accommodate such Islamic and cultural factors. If we are to develop a completely new district away from the current concrete dominating neighbourhoods, then exploring the use of passive cooling and traditional ventilation techniques can be useful. One of today's problems is the current building materials and street materials that greatly contribute to the heat island effect created in current cities.
>
> Traditions are important but not the only requirement for buildings. Inflexible implementation of traditional criteria might be inefficient. If a traditional way of building is 10 per cent or less ineffective in energy savings compared to the most sustainable method, then the traditional way is to be preferred, otherwise not.

6.2.9 Privacy in Saudi Culture

The following question was posed to the participants in the first Delphi round regarding the importance of privacy in the Saudi culture:

> One of the crucial design features to incorporate into the design of a Saudi house is privacy. Privacy can be achieved by the following:

1. Adopting the concept of the courtyard and applying it to the design
2. Utilising the Mashrabiyas and covering exterior windows with them
3. Each block of a Saudi neighbourhood should have a common area to use for gathering and parties, leaving the house for personal and family use
4. Enforcing the use of landscaping on the exterior parameters of the house and it must be at a certain height that gives privacy to the inhabitants from the eyes of outsiders
5. Provision of clear-story fenestration along the room walls instead of typical windows
6. Designing the house entrance with an L-shaped entrance corridor.

The responses are displayed in Table 6.10.

Table 6.10

Responses to the Privacy Question in Round 1

	Median	Mean	Mode	Standard Deviation	Variance	Min	Max	Rank
Adopting the courtyard design	5	4.88	5	1.09	1.19	2	6	Medium
Landscaping the exterior parameters	5	4.64	5	1.11	1.24	2	6	
Neighborhood common area	5	4.56	5	1.29	1.67	1	6	
Utilizing the Mashrabiyas	5	4.44	5	1.08	1.17	2	6	
Provision of clearstory fenestration	5	4.4	5	1.35	1.83	1	6	
L shaped entrance corridor	4	4	5	1.44	2.08	1	6	

All of the privacy in Saudi culture elements were ranked as medium, but the ranking according to the mean and SD values is as follows:

- Adopting the concept of the courtyard and applying it to the design
- Enforcing the use of landscaping on the exterior parameters of the house and it must be at a certain height that gives privacy to the inhabitants from the eyes of outsiders
- Each block of a Saudi neighbourhood should have a common area to use for gathering and parties, leaving the house for personal and family use
- Utilising the Mashrabiyas and covering exterior windows with them
- Provision of clear-story fenestration along the room walls instead of typical windows
- Designing the house entrance with an L-shaped entrance corridor.

Comments from participants included the following:

> The above-mentioned points are an ideal situation. However, they may be hard to be completely accepted and implemented, especially given that designers have to adhere to current municipality and civil department requirements which contradict some of the points.
>
> Enforcing the use of landscaping on the exterior parameters of the house might not be important if the house design features the Mashrabiya and the courtyard. Landscaping then can only be applicable to public spaces.
>
> Provision of clear-story fenestration along the room walls is very good and must be studied well according to the location of the windows and if there is a courtyard in the house or not.

6.2.10 Affordability

The following question was posed to the participants in the first Delphi round regarding the importance of affordability of sustainable housing in Saudi Arabia:

> Sustainable houses, according to the literature, should be affordable to all levels of residents. Please select the appropriate level of agreement to the following elements:

1. Public loans provided by the Saudi Government are not enough to buy a piece of land nor a completed/finished house
2. Promotions for a sustainable lifestyle and advertising via environmental agencies can promote and sponsor portions of the real estate
3. Offering more vacant lands for residential purposes will help decrease the price range and change the density ratio
4. No low- and middle-income family can afford to buy a house in today's market. They all are borrowing money from somewhere to buy houses

5. Saudi residents who cannot afford to build or buy a house straight off the market should build their house gradually room by room
6. The Saudi Government should intervene by reducing land prices
7. The Saudi Government should present affordable housing projects
8. The Saudi Government should plan for smaller land sizes so that residents can afford them
9. The Saudi Government should pay the upfront payment of sustainable housing projects to promote the use of sustainable housing
10. Materials that will be used in sustainable houses need to be sustainable from fabrication to demolition
11. Renting a sustainable house can be affordable to low and middle-income families
12. Closeness and availability of public transport can have a great impact on the sustainability of a house.

The responses are displayed in Table 6.11.

Table 6.11

Responses to the Affordability Question in Round 1

	Median	Mean	Mode	Standard Deviation	Variance	Min	Max	Rank
Provision of affordable housing projects	6	5.44	6	0.65	0.42	4	6	High
Materials must be sustainable from fabrication to demolition	5	5.28	6	0.74	0.54	4	6	
Reducing land prices	6	5.12	6	1.27	1.61	2	6	
Middle and low-income families can't afford	6	5.08	6	1.19	1.41	2	6	
Closeness and availability of public transport	5	4.96	4	0.84	0.71	4	6	Medium
Renting can be affordable for low and mid-income families	5	4.96	5	0.98	0.96	3	6	

	Median	Mean	Mode	Standard Deviation	Variance	Min	Max	Rank
SG pay the upfront payment of sustainable housing	5	4.88	6	1.24	1.53	1	6	
Public loans not enough	5	4.72	6	1.37	1.88	2	6	
Offering more vacant lands	5	4.64	6	1.47	2.16	1	6	
Promotions for a sustainable lifestyle	5	4.44	5	1.08	1.17	2	6	
Plan for smaller land sizes	5	4.4	5	1.5	2.25	1	6	
Build houses gradually, room by room	4	3.64	4	1.68	2.82	1	6	Low

The highest ranked factor was 'The Saudi Government should present affordable housing projects', according to the mean value of 5.44. The participants also ranked the following factors high:

- The Saudi Government should present affordable housing projects
- Materials that will be used in sustainable houses need to be sustainable from fabrication to demolition
- The Saudi Government should intervene by reducing land prices
- No low- and middle-income family can afford to buy a house in today's market. They all are borrowing money from somewhere to buy houses.

One of the most confronting statements for the participants was: 'Saudi residents who cannot afford to build or buy a house straight off the market should build their house gradually room by room'. Many participants did not agree with this factor because the majority stated that Saudi residents could not even afford to build one room to begin with (see Figure 6.8).

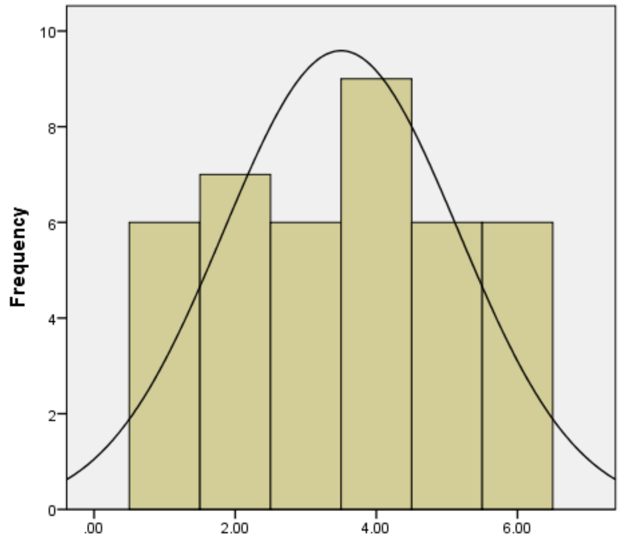

Figure 6.8. Lowest ranked affordability factor.

A participant commented that the factors mentioned above require the proper infrastructure. Lands are phenomenally high-priced in major cities, so the Government is highly encouraged to invest in the infrastructure of small cities and towns to reduce local migration to major cities, which are already crowded and require many initiatives before looking into the problem of land price increase. Another participant stated that people with no money should be given the chance to study and have access to cheap accommodation. After this process, they can help society more effectively and then afford a building. The reduction of land prices is important but only in combination with limits for property amounts. There are many ways to increase the building of sustainable houses and common houses but to find the right methods requires further investigation. All sustainability criteria are important and need to be implemented, as suggested by one participant.

6.3 DELPHI ROUND 2 FINDINGS AND DISCUSSION

After analysing the first Delphi round, the second round was designed to obtain the respondents' consensus on the elements that did not reach consensus in the first round and were either ranked high, medium or low. In the second Delphi round, there was an eight-section survey with a total of 55 elements that asked participants to either agree on the current rankings or re-rank them according to their desire. The remaining sections that were not included in the second round already reached consensus in the previous round.

There are several ways to determine if consensus has been reached or not. Hsu and Sandford (2007. p. 4) state that

> Consensus on a topic can be decided if a certain percentage of the votes falls within a prescribed range'. One criterion recommends that consensus is achieved by having 80 per cent of subjects' votes fall within two categories on a 7-point scale (Ulschak, 1983). Green (1982) suggests that at least 70 per cent of Delphi subjects need to rate at 3 or higher on a 4-point Likert-type scale and the median has to be 3.25 or higher. Scheibe, Skutsch and Schofer (1975) argue that the use of percentage measures is inadequate. They suggest that a more reliable alternative is to measure the stability of subjects' responses in successive iterations.

In this research, a 70 per cent agreement will be considered consensus. Additionally, as part of the analysis to reach consensus, any element that is originally ranked medium and then re-ranked high, but whose percentage is almost split between these two ranks, will be considered high-medium value. Conversely, if an element is originally ranked medium and part of the participants re-rank that element to be low, then that element will be considered low-medium value. If the majority rank the element to be medium, then that element will remain at medium value.

The second Delphi round was designed around the categories that had reached non-consensus, ranging between high, medium and low. There were a total of 35 participants that continued to the second round, meaning a total of 12 participants dropped out after the first round. The second round consisted of eight sections (the remaining two sections having reached consensus in the first round):

1. Definition
2. Sustainability factors
3. Barriers
4. Enablers
5. SBC
6. ~~Saudi Government~~ (reached consensus in round 1)
7. Environmental factors
8. Saudi Culture
9. ~~Privacy in Saudi culture~~ (reached consensus in round 1)
10. Affordability.

Each of the eight survey sections is discussed and the results are displayed as follows, and the remaining two sections that have reached consensus will be shown on the grounds of that consensus. Additionally, some of the indicators were ranked high in the first round but were tested again to verify the responses and reach consensus in the second round because they had a SD value greater than 1.

6.3.1 Definition

The question was the same as in the first Delphi round, and the responses are displayed in Table 6.12.

Table 6.12

Responses to the Definition Question in Round 2

Factor Level	Factor	Level of Agreement	Sum	Percentage from round 2 out of 35 participants	Total Percentage out of 47 participants
High	**Energy efficient**	Agree (High)	25	71.43%	53.19%
		Medium	10	28.57%	21.28%
		Low	0	0.00%	0.00%
	Employing (absorbing) the local weather	Agree (High)	25	71.43%	53.19%
		Medium	9	25.71%	19.15%
		Low	1	2.86%	2.13%
Medium	**Suitable for the local environment and cultures**	Agree (Medium)	19	54.29%	40.43%
		High	15	42.86%	31.91%
		Low	1	2.86%	2.13%
	Built from local materials	Agree (Medium)	18	51.43%	38.30%
		High	15	42.86%	31.91%
		Low	2	5.71%	4.26%
	Affordable to the consumer	Agree (Medium)	16	45.71%	34.04%
		High	18	51.43%	38.30%
		Low	1	2.86%	2.13%

The following elements reached consensus to be ranked as high:

- energy efficiency
- employing (absorbing) the local weather.

To conclude the analysis of the definition question, two elements reached consensus to be ranked as high in the first round:

- environmentally friendly
- low-cost, long-term maintenance.

6.3.2 Sustainability Factors

The question was the same as in the first Delphi round and the responses are displayed in Table 6.13.

Table 6.13

Responses to the Sustainability Factors Question in Round 2

Factor Level	Factor	Level of Agreement	Sum	Percentage from round 2 out of 35 participants	Total Percentage out of 47 participants
High	Thermal Insulation	Agree (High)	34	97.14%	72.34%
		Medium	0	0.00%	0.00%
		Low	1	2.86%	2.13%
	Indoor Air Quality	Agree (High)	33	94.29%	70.21%
		Medium	1	2.86%	2.13%
		Low	1	2.86%	2.13%
	Passive Cooling (Less use of mechanical cooling)	Agree (High)	32	91.43%	68.09%
		Medium	2	5.71%	4.26%
		Low	1	2.86%	2.13%
	Structural Quality	Agree (High)	18	51.43%	38.30%
		Medium	7	20.00%	14.89%
		Low	10	28.57%	21.28%
Medium	Physical Health (Well-being)	Agree (Medium)	31	88.57%	65.96%
		High	4	11.43%	8.51%
		Low	0	0.00%	0.00%
	Accessibility (Near all amenities)	Agree (Medium)	26	74.29%	55.32%
		High	7	20.00%	14.89%
		Low	2	5.71%	4.26%
	Low Maintenance Cost	Agree (Medium)	26	74.29%	55.32%
		High	8	22.86%	17.02%
		Low	1	2.86%	2.13%
	Mental Health	Agree (Medium)	26	74.29%	55.32%
		High	5	14.29%	10.64%
		Low	4	11.43%	8.51%
	Grey/Rain Water Treatment	Agree (Medium)	16	45.71%	34.04%
		High	18	51.43%	38.30%
		Low	1	2.86%	2.13%
	Use of Green Energy	Agree (Medium)	14	40.00%	29.79%
		High	20	57.14%	42.55%
		Low	1	2.86%	2.13%
	Recycling	Agree (Medium)	14	40.00%	29.79%

Factor Level	Factor	Level of Agreement	Sum	Percentage from round 2 out of 35 participants	Total Percentage out of 47 participants
	Material (Waste)	High	21	60.00%	44.68%
		Low	0	0.00%	0.00%
Low	Low Initial Cost	Agree (Low)	31	88.57%	65.96%
		High	1	2.86%	2.13%
		Medium	3	8.57%	6.38%
	High Maintenance Cost	Agree (Low)	21	60.00%	44.68%
		High	12	34.29%	25.53%
		Medium	2	5.71%	4.26%
	High Initial Cost	Agree (Low)	14	40.00%	29.79%
		High	18	51.43%	38.30%
		Medium	3	8.57%	6.38%

The following elements reached consensus to be ranked as high:

- thermal insulation
- indoor air quality
- passive cooling (less use of mechanical cooling).

6.3.3 Barriers

The question was the same as in the first Delphi round and the responses are displayed in Table 6.14.

Table 6.14

Responses to the Barriers Question in Round 2

Factor Level	Factor	Level of Agreement	Sum	Percentage from round 2 out of 35 participants	Total Percentage out of 47 participants
High	Lack of public awareness on the benefits of sustainable housing	Agree (High)	33	94.29%	70.21%
		Medium	1	2.86%	2.13%
		Low	1	2.86%	2.13%
Medium	Lack of awareness from designing firms of how to design sustainable housing	Agree (Medium)	25	71.43%	53.19%
		High	6	17.14%	12.77%
		Low	4	11.43%	8.51%
	Lack of Government Support (Guidelines, Building Codes)	Agree (Medium)	23	65.71%	48.94%
		High	11	31.43%	23.40%
		Low	1	2.86%	2.13%
	Lack of alternative designs of housing	Agree (Medium)	21	60.00%	44.68%
		High	7	20.00%	14.89%
		Low	7	20.00%	14.89%
	Low levels of investment in sustainable housing	Agree (Medium)	14	40.00%	29.79%
		High	21	60.00%	44.68%
		Low	0	0.00%	0.00%
	High initial cost of sustainable housing	Agree (Medium)	13	37.14%	27.66%
		High	19	54.29%	40.43%
		Low	3	8.57%	6.38%
	Lack of Financial incentives (Subsidies)	Agree (Medium)	8	22.86%	17.02%
		High	26	74.29%	55.32%
		Low	1	2.86%	2.13%
Low	Shortage in sustainable construction material	Agree (Low)	27	77.14%	57.45%
		High	4	11.43%	8.51%
		Medium	4	11.43%	8.51%
	Long period of return of investment (Payback period)	Agree (Low)	15	42.86%	31.91%
		High	14	40.00%	29.79%
		Medium	6	17.14%	12.77%

The following barriers reached consensus to be ranked as high:

- Lack of public awareness of the benefits of sustainable housing
- Lack of financial incentives (subsidies, insurance discounts, bank loans, etc.).

6.3.4 Enablers

The question was the same as in the first Delphi round and the following enablers reached consensus to be ranked as high:

- Educating the public on the advantages of sustainable housing
- Applying sustainable construction methods that meet the environmental comfort needs of residents
- Educating firms on how to design sustainable housing.

  The responses to the remaining enablers are displayed in Table 6.15.

Table 6.15

Responses to the Enablers Question in Round 2

Factor Level	Factor	Level of Agreement	Sum	Percentage from round 2 out of 35 participants	Total Percentage out of 47 participants
High	Implementing new laws that enforce sustainable methods	Agree (High)	33	94.29%	70.21%
		Medium	0	0.00%	0.00%
		Low	2	5.71%	4.26%
	The Saudi government should provide financial incentives	Agree (High)	32	91.43%	68.09%
		Medium	2	5.71%	4.26%
		Low	1	2.86%	2.13%
Medium	A resident in a Saudi neighborhood should have all his/her basic needs within walking distance	Agree (Medium)	26	74.29%	55.32%
		High	7	20.00%	14.89%
		Low	2	5.71%	4.26%
	The Saudi government provision of affordable sustainable housing units	Agree (Medium)	22	62.86%	46.81%
		High	10	28.57%	21.28%
		Low	3	8.57%	6.38%
	Green energy should be the main energy source	Agree (Medium)	13	37.14%	27.66%
		High	19	54.29%	40.43%
		Low	3	8.57%	6.38%
	Enforce Rainwater collection and Grey water treatment systems	Agree (Medium)	13	37.14%	27.66%
		High	20	57.14%	42.55%
		Low	2	5.71%	4.26%

The following enablers reached consensus to be ranked as high:

- The Saudi Government should provide financial incentives (subsidies) to whoever applies sustainable construction methods to their house
- Implementing new laws that enforce the utilisation of sustainable methods to housing construction.

6.3.5 The Saudi Building Code

The question was the same as in the first Delphi round and the following SBC factors reached consensus to be ranked as high:

- All designing firms should have a good understanding of the SBC.

The responses to the remaining SBC factors are displayed in Table 6.16.

Table 6.16

Responses to the SBC Question in Round 2

Factor Level	Factor	Level of Agreement	Sum	Percentage from round 2 out of 35 participants	Total Percentage out of 47 participants
High	New housing projects must use the Saudi building code	Agree (High)	34	97.14%	72.34%
		Medium	0	0.00%	0.00%
		Low	1	2.86%	2.13%
Medium	Existing houses need to be renovated to reach the minimum level required by the Saudi building code	Agree (Medium)	25	71.43%	53.19%
		High	6	17.14%	12.77%
		Low	4	11.43%	8.51%
	Increase public awareness of the Saudi building code, e.g. through local media	Agree (Medium)	23	65.71%	48.94%
		High	10	28.57%	21.28%
		Low	2	5.71%	4.26%
Low	The Saudi Building Code is new to Stakeholders and have not used it or had any experience with it	Agree (Low)	32	91.43%	68.09%
		High	3	8.57%	6.38%
		Medium	0	0.00%	0.00%
	Stakeholders have extensive knowledge of the Saudi Building Code	Agree (Low)	29	82.86%	61.70%
		High	4	11.43%	8.51%
		Medium	2	5.71%	4.26%
	Stakeholders use the Saudi Building Code constantly	Agree (Low)	29	82.86%	61.70%
		High	3	8.57%	6.38%
		Medium	3	8.57%	6.38%
	The Saudi Public has knowledge	Agree (Low)	27	77.14%	57.45%
		High	2	5.71%	4.26%

Factor Level	Factor	Level of Agreement	Sum	Percentage from round 2 out of 35 participants	Total Percentage out of 47 participants
	about the Saudi Building Code	Medium	6	17.14%	12.77%
	Saudi Architectural designing firms don't use the Saudi Building Code	Agree (Low)	23	65.71%	48.94%
		High	8	22.86%	17.02%
		Medium	4	11.43%	8.51%

The following SBC element reached consensus to be ranked as high:

- New housing projects must use the SBC at least to the minimum standards.

6.3.6 Saudi Government

In the first Delphi round, all of the Saudi Government factors reached consensus to be ranked as low, so this question was not re-asked in the second round.

6.3.7 Environmental Factors

The question was the same as in the first Delphi round. In round 1, the following environmental factors reached consensus to be ranked as high:

- energy saving
- thermal comfort
- thermal insulation
- affordability
- water conservation
- site orientation
- passive cooling.

The responses to the remaining factors are displayed in Table 6.17.

Table 6.17.

Responses to the Environmental Factors Question in Round 2

Factor Level	Factor	Level of Agreement	Sum	Percentage from round 2 out of 35 participants	Total Percentage out of 47 participants
Medium	Landscape	Agree (Medium)	30	85.71%	63.83%
		High	3	8.57%	6.38%
		Low	2	5.71%	4.26%
	Water insulation (Interior insulation)	Agree (Medium)	30	85.71%	63.83%
		High	3	8.57%	6.38%
		Low	2	5.71%	4.26%
	Privacy	Agree (Medium)	17	48.57%	36.17%
		High	16	45.71%	34.04%
		Low	2	5.71%	4.26%

The following environmental factors reached consensus to be ranked as medium, in addition to the factors that reached consensus in the first round:

- landscape
- water insulation (interior insulation).

6.3.8 Saudi Culture

The question was the same as in the first Delphi round. In round 1, the following Saudi culture factors reached consensus to be ranked as high:

- The traditional courtyard was not just an architectural element. It had social impacts as well. For example, it was a gathering place for the whole family
- Courtyards can be used to ventilate the house as well as provide natural lighting to adjacent rooms

In round 1, the following Saudi culture factors reached consensus to be ranked as medium:

- Mashrabiyas can be designed in an efficient and modern way and can be incorporated into the design of a Saudi house
- Passive cooling can be achieved utilising the techniques behind vernacular elements such as wind towers.

The responses to the remaining Saudi culture factors are displayed in Table 6.18.

Table 6.18

Responses to the Saudi Culture Question in Round 2

Factor Level	Factor	Level of Agreement	Sum	Percentage from round 2 out of 35 participants	Total Percentage out of 47 participants
Medium	Vernacular architectural elements should be incorporated in today's housing design	Agree (Medium)	28	80.00%	59.57%
		High	4	11.43%	8.51%
		Low	3	8.57%	6.38%
	Saudi Arabia's unique Islamic culture is not reflected in many designs of modern houses	Agree (Medium)	25	71.43%	53.19%
		High	9	25.71%	19.15%
		Low	1	2.86%	2.13%

The following Saudi culture factors reached consensus to be ranked as medium, in addition to the factors that reached consensus in the first round:

- Saudi Arabia's unique Islamic culture is not reflected in many designs of modern houses
- Vernacular architectural elements should be incorporated in today's housing design.

6.3.9 Privacy in Saudi Culture

The question was the same as in the first Delphi round. In the first Delphi round, all of the factors reached consensus to be ranked as medium, so this question was not re-asked in the second round.

6.3.10 Affordability

The question was the same as in the first Delphi round. In round 1, the following affordability factors reached consensus to be ranked as high:

- The Saudi Government should present affordable housing projects
- Materials that will be used in sustainable houses need to be sustainable from fabrication to demolition.

In round 1, the following affordability factors reached consensus to be ranked as medium:

- Renting a sustainable house can be affordable to low- and middle-income families
- Closeness and availability of public transport can have a great impact on the sustainability of a house.

The responses to the remaining affordability factors are displayed in Table 6.19.

Table 6.19

Responses to the Affordability Question in Round 2

Factor Level	Factor	Level of Agreement	Sum	Percentage from round 2 out of 35 participants	Total Percentage out of 47 participants
High	No middle and low-income family can afford to buy a house in today's market.	Agree (High)	33	94.29%	70.21%
		Medium	0	0.00%	0.00%

Factor Level	Factor	Level of Agreement	Sum	Percentage from round 2 out of 35 participants	Total Percentage out of 47 participants
	They all are borrowing money from somewhere to buy houses	Low	2	5.71%	4.26%
	The Saudi government should intervene by reducing land prices	Agree (High)	32	91.43%	68.09%
		Medium	0	0.00%	0.00%
		Low	3	8.57%	6.38%
Medium	**Promotions for a sustainable lifestyle and advertising via environmental agencies can promote and sponsor portions of the real estate**	Agree (Medium)	32	91.43%	68.09%
		High	0	0.00%	0.00%
		Low	3	8.57%	6.38%
	The Saudi government should pay the upfront payment of sustainable housing projects to promote the use of sustainable housing	Agree (Medium)	31	88.57%	65.96%
		High	3	8.57%	6.38%
		Low	1	2.86%	2.13%
	Public loans provided by the Saudi government are not enough to buy a piece of land nor a completed/finished house	Agree (Medium)	16	45.71%	34.04%
		High	16	45.71%	34.04%
		Low	3	8.57%	6.38%
	Offering more vacant lands for residential purposes will help decrease the price range and change the density ratio	Agree (Medium)	15	42.86%	31.91%
		High	17	48.57%	36.17%
		Low	2	5.71%	4.26%
	The Saudi government should plan for smaller land sizes so that residents can afford them	Agree (Medium)	14	40.00%	29.79%
		High	16	45.71%	34.04%
		Low	5	14.29%	10.64%
Low	**Saudi residents who can't afford to build or buy a house straight off the market, should build their house gradually room by room**	Agree (Low)	24	68.57%	51.06%
		High	5	14.29%	10.64%
		Medium	6	17.14%	12.77%

The following affordability factors reached consensus to be ranked as high, in addition to the factors that reached consensus in the first round:

- The Saudi Government should intervene by reducing land prices

- No low- and middle-income family can afford to buy a house in today's market. They all are borrowing money from somewhere to buy houses.

The following affordability factors reached consensus to be ranked as medium, in addition to the factors that reached consensus in the first round:

- The Saudi Government should pay the upfront payment of sustainable housing projects to promote the use of sustainable housing
- Promotions for a sustainable lifestyle and advertising via environmental agencies can promote and sponsor portions of the real estate.

6.4 DISCUSSION

The two Delphi rounds have generally provided important insights and are greatly related and connected to the research questions and objectives. An overall 61 per cent consensus was reached after the two rounds were finalised and analysed. A further 20 per cent of the responses gained an overall consensus of more than 50 per cent but less than 70 per cent. The remaining 19 per cent of the elements did not reached consensus and the overall agreement levels were below 50 per cent.

Table 6.20 illustrates the percentages that reached consensus compared to the non-consensus elements. The first Delphi round was analysed in a quantitative descriptive statistic method using the median, mean, mode, standard deviation and variance and the outcome from this Delphi round are presented in Table 6.21. Additionally, the second Delphi round was analysed using the frequency method and the outcomes are also displayed in Table 6.22.

Table 6.20

Consensus Percentages According to Delphi Rounds

	Consensus from Round 1	Consensus from Round 2	Consensus from Round 2 due to changing from Medium to High	Remaining non-consensus elements	Sum
Total number of questions	29	29	19	18	95
Percentage Reached	30.53%	30.53%	20.00%	18.95%	100.00%

Table 6.21

Outcomes from the First Delphi Round

Factor Category	First Delphi round (High Level) Or All Agreed on One Level
Definition	Environmentally Friendly
	Has Low-Cost Long-Term Maintenance
	Energy Efficient
	Employing (Absorbing) the Local Weather
Sustainability	Natural Lighting
	Water Conservation
	Natural Ventilation
	Thermal Comfort
	Site Orientation
	Optimum use of Local material
	Thermal Insulation
	Indoor Air Quality
	Passive Cooling (Less use of mechanical cooling)
	Structural Quality
Barriers	Lack of public awareness on the benefits of sustainable housing
Enablers	Educating the public on the advantages of sustainable housing
	Applying sustainable construction methods that meet the environmental comfort needs of residents
	Educating firms on how to design sustainable housing
	The Saudi government should provide financial incentives
	Implementing new laws that enforce the utilization of sustainable methods to housing construction
The Saudi Building Code	All designing firms should have a good understanding of the Saudi building code
	New housing projects must use the Saudi building code at least to the minimum standards
The Saudi Government (Low Level Ranking Agreement)	The Saudi government intervenes in the design and construction of houses in Saudi Arabia
	Acknowledgement by the Saudi government and other official bodies in Saudi regarding “change” in the ideas of the Saudi population regarding the application of sustainable methods on housing
Environmental Factors	Energy Saving
	Thermal Comfort
	Thermal Insulation
	Cost Saving
	Water conservation
	Site Orientation
	Passive Cooling
The Saudi Culture	Courtyards can be used to ventilate the house as well as provide natural lighting to adjacent rooms

Factor Category	First Delphi round (High Level) Or All Agreed on One Level
	The traditional courtyard was not just an architectural element. It had social impacts as well
Privacy (Medium Level Ranking Agreement)	Adopting the concept of the courtyard
	Enforcing the use of landscaping on the exterior parameters of the house
	Each block of a Saudi neighborhood should have a common area to use for gathering and parties
	Utilizing the Mashrabiyas and covering exterior windows with them
	Provision of clearstory fenestration along the room walls instead of typical windows
	Designing the house entrance with an L shaped entrance corridor
Affordability	The Saudi government should present affordable housing projects
	Materials that will be used in sustainable houses need to be sustainable from the fabrication to demolition

Table 6.22

Outcomes from the Second Delphi Round

Factor Category	Second Delphi round (Consensus)
Definition	Energy Efficient
	Employing (Absorbing) the Local Weather
Sustainability	Thermal Insulation
	Indoor Air Quality
	Passive Cooling (Less use of mechanical cooling)
Barriers	Lack of public awareness on the benefits of sustainable housing
	Lack of Financial incentives (Subsidies, Insurance discounts, bank loans, etc.)
Enablers	The Saudi government should provide financial incentives
	Implementing new laws that enforce the utilization of sustainable methods to housing construction
The Saudi Building Code	New housing projects must use the Saudi building code at least to the minimum standards
The Saudi Government (Low Level Ranking Agreement)	Reached consensus in the First Delphi round
Environmental Factors	Landscape (Medium Level Consensus)
	Water insulation (Interior insulation) (Medium Level Consensus)
The Saudi Culture	Saudi Arabia's unique Islamic culture is not reflected in many designs of modern houses (Medium Level Consensus)
	Vernacular architectural elements should be incorporated in today's housing design (Medium Level Consensus)
Privacy (Medium Level Ranking Agreement)	Reached consensus in the First Delphi round
Affordability	The Saudi government should intervene by reducing land prices
	No middle and low-income family can afford to buy a house in today's market

More than 61 per cent of factors reached consensus among the panel members, with the possibility of reaching more than 81 per cent because the remaining 20 per cent were changed from medium to high, which means that the participants reconsidered their ranking and further emphasised the importance of the particular element. Thus, this thesis concludes that since the two carried-out Delphi rounds have obtained a general consensus of more than 81 per cent, then the objectives form these two Delphi rounds have been fulfilled.

6.5 SUMMARY

This chapter detailed the results from the two Delphi rounds that were conducted as the main research method of this thesis. The objective of carrying out two Delphi rounds was to reach consensus on a set of questions that related to the research questions and objectives. The two Delphi rounds consisted of 10 sections, with an eleventh section on the demographic information of the participants.

Ultimately, 81 per cent consensus was reached on the elements. The remaining 19 per cent did not reach consensus, but this is considered reasonable because reaching an overall 100 per cent consensus is improbable due to different perspectives from different participants. Chapter 8 discusses the connection of these results to the research questions and objectives. The following chapter presents the third data collection method utilised in this thesis, which is case study analysis.

Chapter 7: Case Study Results

7.1 INTRODUCTION

The third research method utilised in this thesis is the case study analysis of three real-life projects that have applied sustainable construction methods. These are compared with a project that is built in the traditional non-sustainable way. This chapter discusses in detail the background of the projects used for the case study analysis and shows the connection to the research questions and objectives.

To set a baseline, the discussion of the case studies begins by examining non-sustainable housing projects typical of the KSA. The project selected is a typical three-bedroom, two-storey detached villa located in the city of Jeddah, of which a concentrated analysis concerns its energy and water consumption. A further review of sustainable projects revolves around the key sustainable housing features, and environmental and cultural factors. The analysis focuses on the following points:

- energy consumption (economic, environmental and application)
- water consumption (economic, environmental and application)
- CO_2 emissions (environmental)
- cultural aspects (socio-cultural)
- building material (economic, environmental and application).

Sustainable projects are considerably new in Saudi Arabia and not many can be used as case studies due to their high-security nature and lack of available sources. For the purpose of this thesis, three residential projects, two of which are in their pre-construction phase, are analysed as case studies. The two pre-construction residential building projects, the Fence house and the Landform house, have total land occupancy of 4150 m^2 combined. The third case study is an apartment building in the city of Jeddah that has utilised simple but effective sustainability measures.

7.2 NON-SUSTAINABLE CASE STUDY ANALYSIS

KAUST has launched ‘The Industry Collaboration Program’ (2013), where collaboration between the university and industry resulted in a comprehensive production report analysing current building performances. Data were presented to the public. The programme has conducted studies on several types of buildings in Saudi Arabia and has analysed those buildings in terms of two main aspects: energy consumption and water consumption. Their report also discusses in detail how to preserve energy and water by promoting alternative passive design aspects and the use of certain technologies to reduce the overall amount of energy and water consumed. Figures 7.1 and 7.2 illustrate the typical layout and form of a house in Jeddah, which was the base of the analysis made by the KAUST Industry Collaboration Program. The house consists of two floors and three bedrooms, and accommodates a family of five members. The ground floor consists of the guest areas and the upper floor consists of the bedroom and family living room.

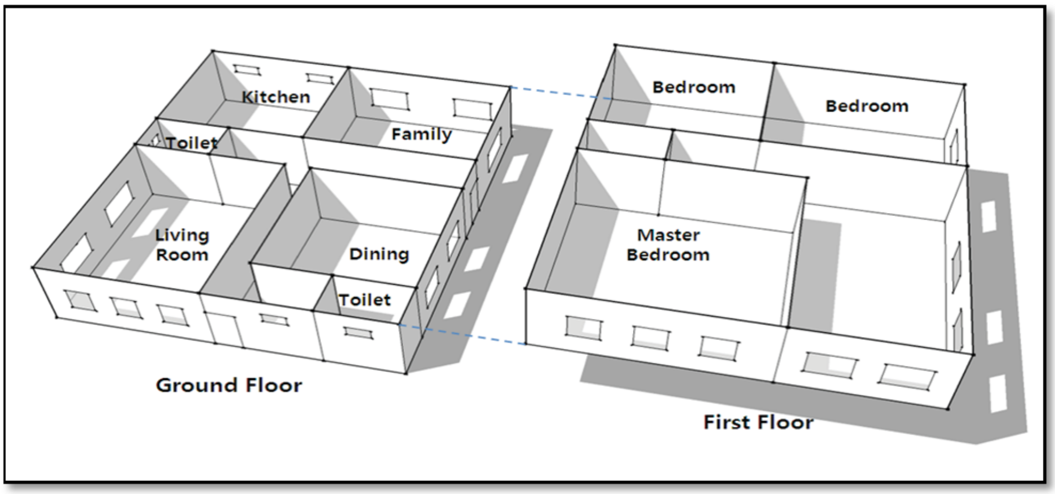

Figure 7.1. Layout and shape of a typical ground floor housing unit in Jeddah. (KAUST Industry Collaboration Program, 2013).

Huge amounts of energy are consumed, mainly due to cooling the interior of the building, as illustrated in Figure 7.2. Lack of thermal insulation prevents heat from entering the building in summer or from exiting the building in winter. The total energy consumption (baseline) of a non-insulated residential building in Jeddah amounts to 1044.6 kWh/m^2 a year, of which 81.7 per cent is used for cooling alone.

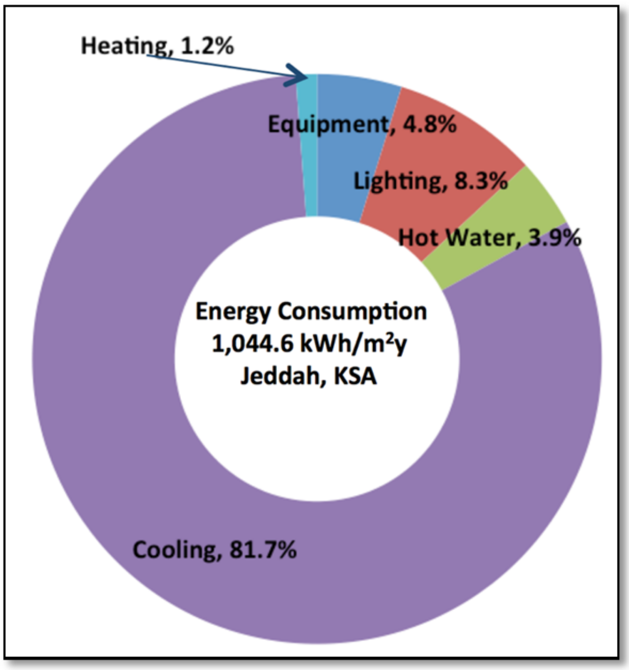

Figure 7.2. Energy consumption of housing unit (non-insulated house) (KAUST Industry Collaboration Program, 2013).

One of the significant energy reduction measures that can be applied is thermal insulation. It was evident from the literature review that energy consumption in Saudi Arabia is ranked as one of the highest worldwide (Aluwaisheg, 2013; Fatha et al., 2013; Husain & Khalil, 2013). Overconsumption is a trend in the Saudi population. It was discussed that government subsides help fuel this attitude due to the cheap price of energy and fossil fuels (see section 2.4.5). However, certain measures can help reduce this consumption, such as the installation of thermal insulation. It was also evident from the semi-structured interviews that heat reduction was the environmental factor of most concern (see section 5.2.6). Energy conservation is also one of the top selected sustainability factors of concern. Moreover, it was revealed from the Delphi rounds that energy saving and thermal insulation are considered high-ranked elements of concern (see section 6.2.7). Figure 7.3 illustrates the amount of energy consumed by the same house if it is insulated.

The total energy consumption (baseline) of an insulated residential building in Jeddah amounts to 588.4 kWh/m^2 a year, of which 70 per cent is used for cooling.

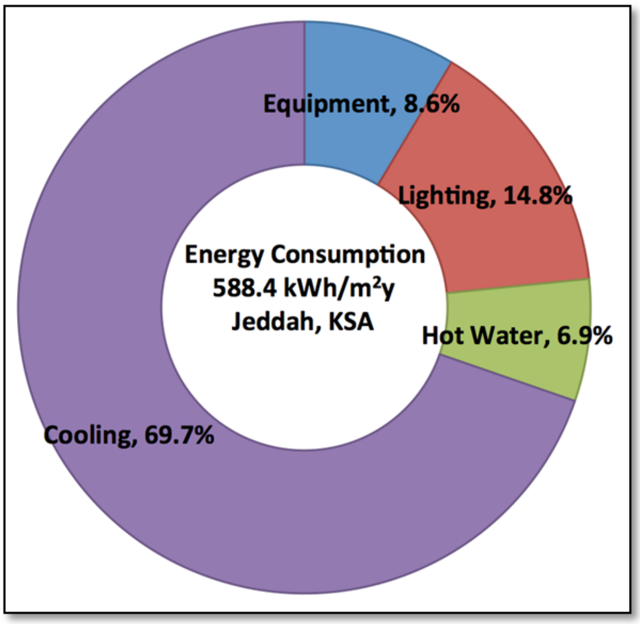

Figure 7.3. Energy consumption of housing unit (insulated house/baseline) (KAUST Industry Collaboration Program, 2013).

To compare sustainable and non-sustainable houses, Table 7.1 shows the energy consumption in a housing unit in Jeddah where it is possible to save more than 50 per cent of the overall energy if sustainability measures are utilised, such as thermal insulation to save on energy consumption and reduction in cooling loads.

Table 7.1

Primary Energy Consumption in Housing Units in Jeddah in kWh/m²y (KAUST Industry Collaboration Program, 2013)

Energy type	Sustainable house	Non-sustainable house
Cooling	410.3 (69.7%)	853.9 (81.7%)
Heating	0.3 (0.1%)	12.9 (1.2%)
Hot water	40.4 (6.8%)	40.4 (3.9%)
Lighting	86.8 (14.8%)	86.8 (8.3%)
Equipment	50.6 (8.6%)	50.6 (4.8%)
Total	588.4 (100.0%)	1044.6 (100.0%)

The percentage of water reduction when utilising sustainable methods such as water-saving devices—for example, in faucets, showerheads and kitchen sinks—can reach up to 49 per cent, as demonstrated in the report by the KAUST Industry Collaboration Program (2013). The installation of a water-saving devices is the easiest way to reduce water consumption, but it incurs a cost burden upon the consumer. Government subsidies or incentives can solve this economic difficulty facing the public. Figure 7.4 provides further evidence of the need for sustainable housing methods to be implemented in Saudi Arabia.

7.3 SUSTAINABLE CASE STUDY 1 ANALYSIS

The first sustainable case study to be analysed is the Fence house. The Fence house is built in an area of 1250 m^2 with a built-up area of 1000 m^2. Table 7.2 shows the project profile in detail. The table shows the energy consumption, water consumption and CO_2 emissions. It is evident from the table that the energy consumption levels are reduced from the baseline by 15 per cent, water consumption levels are reduced by 29 per cent, and the overall CO_2 emissions are reduced by 24 per cent. In addition, 8 per cent of renewable energy is produced on-site by PV panels.

Table 7.2

Case Study 1 Profile

Project		**Fence House**
Land Area		1250 m^2
Built-up Area		1000 m^2
Energy Consumption	**Baseline Consumption**	161 KWH/Year
	Design Consumption	136 KWH/Year
	Percentage Saved	15%
% of Renewable Energy From PV Panels		8%
Water Consumption	**Baseline Consumption**	2900 L/Day
	Design Consumption	2200 L/Day
	Percentage Saved	29%
CO_2 Emissions	**Baseline Emissions**	153,000 KG/Year
	Design Emissions	117,000 KG/Year
	Percentage Saved	24%

In addition to the three elements discussed in Table 7.2, the fourth element to analyse in this case study is the cultural aspect. The Fence house, as we see in Figure 7.4, has implemented the courtyard typology of the traditional Saudi house, as discussed earlier in Chapter 3, where the house looks inward onto a courtyard rather than outward. This typology is common in Saudi Arabia because this design provides privacy for the residents. This feature has been carefully considered in the Fence house, where the courtyard was designed to be a beautiful garden in addition to serving the function of privacy.

Figure 7.4. The Fence house (Dada, 2013).

Figure 7.4 is a 3D model of the Fence house that was designed by ‘The Other Dada’, and Figure 7.5 shows a perspective of the courtyard in the Fence house. Figure 7.6 illustrates the airflow through the house utilising the courtyard design. It also illustrates how the landscape on the exterior of the fence helps to provide visual privacy as well as a dust filter. It further shows how the sunlight is well considered and shading is provided in areas where it is most needed, such as on the south and west sides of the house.

Figure 7.5. Courtyard perspective of the Fence house (Dada, 2013).

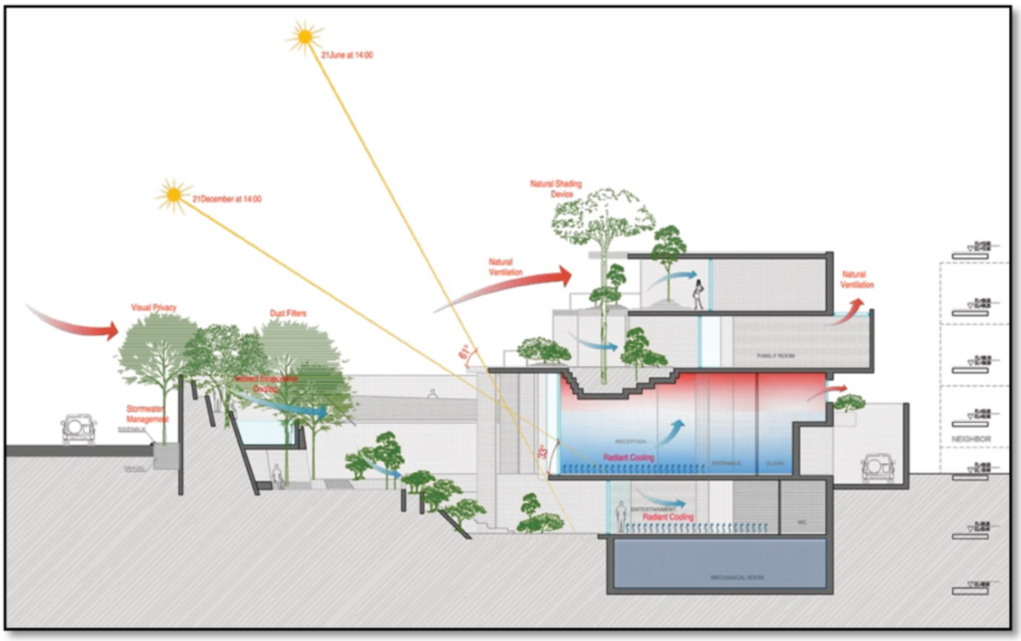

Figure 7.6. Wind flow and day lighting in the Fence house (Dada, 2013).

The Fence house design has considered several sustainability measures and elements such as energy saving, harvesting daylight and passive cooling. However, one thing that is not considered sustainable is the affordability of this house. The cost of designing and building this house is far higher than what low- or middle-income families can afford in the current Saudi Arabian real estate market. Hence, it is recommended that future housing designs consider affordability in addition to the other elements tackled by the design of the Fence house.

7.4 SUSTAINABLE CASE STUDY 2 ANALYSIS

The second case study to be analysed is the Landform house. The Landform house is built in an area of 2900 m^2 with a built-up area of 1800 m^2. Table 7.3 shows the project profile in detail, where the energy consumption levels are reduced by 27 per cent from the baseline, water consumption levels are reduced by 29 per cent, and the overall CO_2 emissions reduced by 29 per cent, in addition to 17 per cent of renewable energy being produced on-site by PV panels.

Table 7.3

Case Study 3 Profile

Project		Landform House
Land Area		2900 m^2
Built-up Area		1800 m^2
Energy Consumption	Baseline Consumption	161 KWH/Year
	Design Consumption	117 KWH/Year
	Percentage Saved	27%
% of Renewable Energy From PV Panels		17%
Water Consumption	Baseline Consumption	4800 L/Day
	Design Consumption	3700 L/Day
	Percentage Saved	29%
CO_2 Emissions	Baseline Emissions	232,000 KG/Year
	Design Emissions	165,000 KG/Year
	Percentage Saved	29%

The Landform house design (see figures 7.7, 7.8 and 7.9) has been approached differently because of the client's needs. The client requested the designer respect the form of the land and design the house around it. This design promoted sustainability by preserving the current landform and not demolishing or excavating any land unnecessarily. The house was designed in relation to the landform in three separate parts: public, private and service area. This design aspect achieves privacy, as discussed in the literature (Al Ghamdi, 1995; Al Hazmi & Nyland, 2010; El-Shorbagy, 2010; North & Tripp, 2009; Weber & Yannas, 2014). It also validates the responses in the semi-structured interviews and the Delphi rounds (see sections 5.2.8 and 6.2.9).

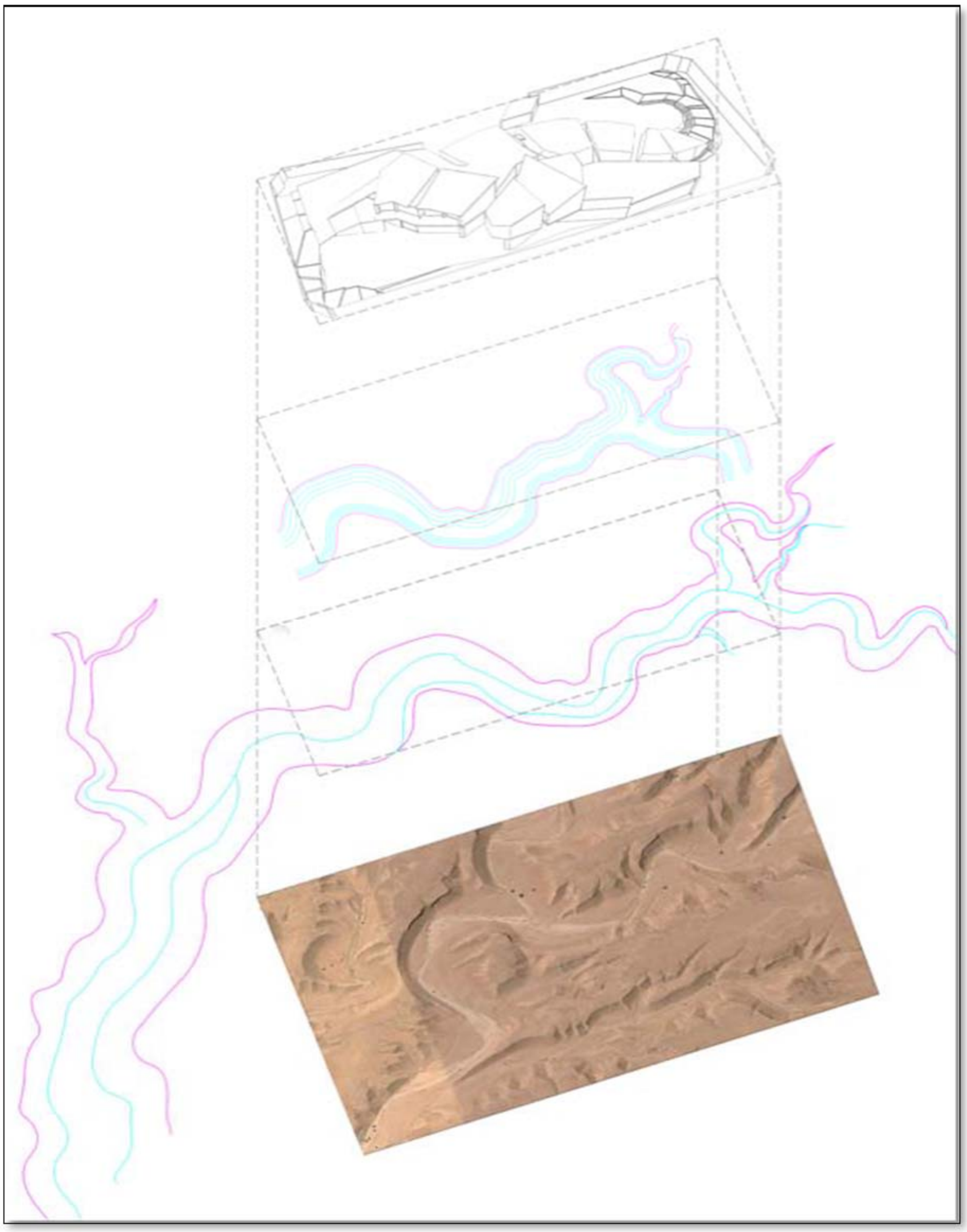

Figure 7.7. Planning of the Landform house (Dada, 2013).

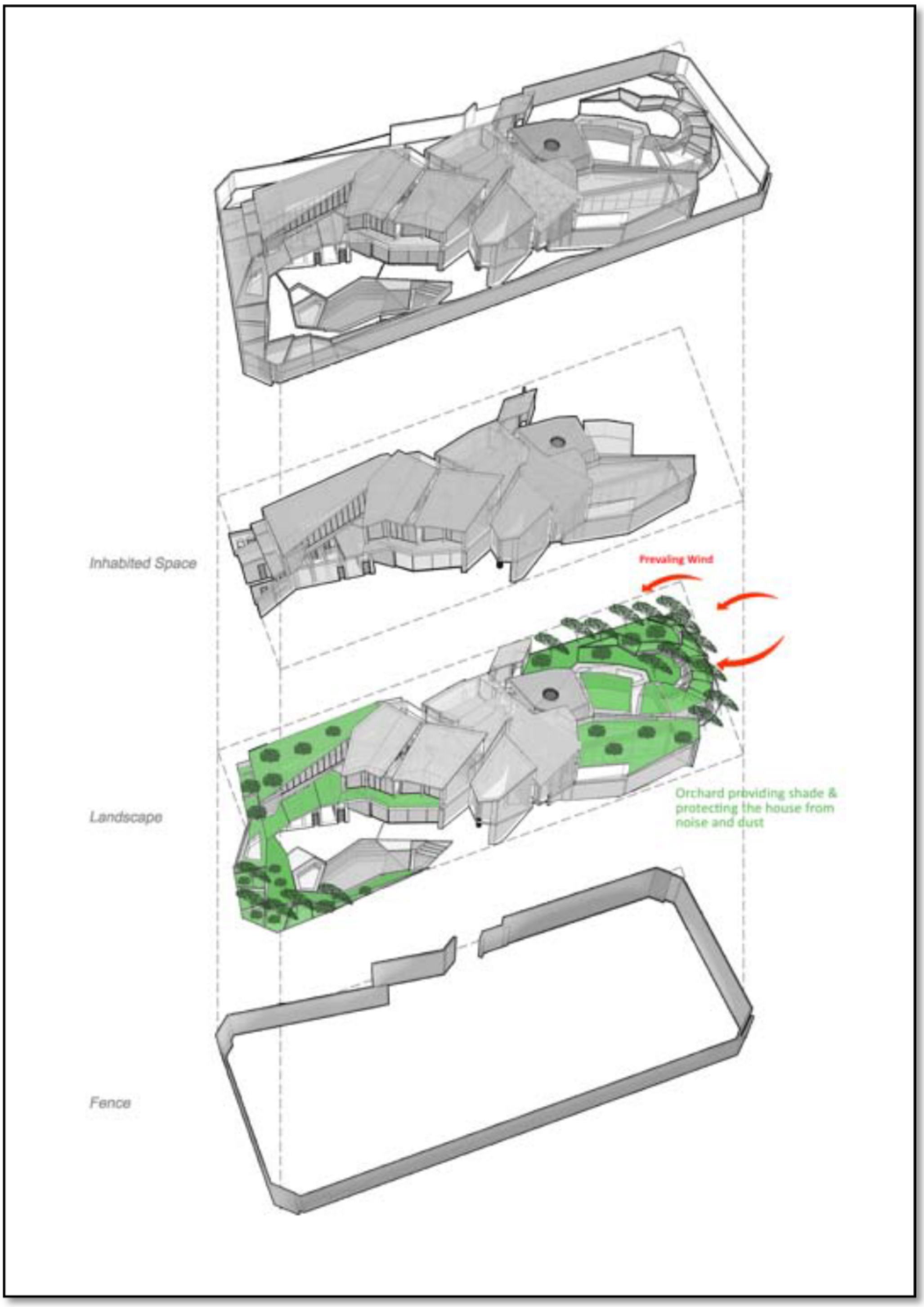

Figure 7.8. Exploded axonometric of the Landform house (Dada, 2013).

Figure 7.9. 3D model of the Landform house (Dada, 2013).

In traditional and historical buildings, landscape was a main part of the design of an Islamic background. This design feature resembled paradise for the occupants, as foretold in the Holy Qur'an. 'Bustan' or 'Jannah', as described in the Holy Qur'an, is a paradise that residents joyfully indulge in within the boundaries of their privately enclosed houses. The Landform house design accomplishes that by introducing a variety of landscaping features from the environment and providing a winding pathway between parts of the house. In addition to respecting the form of the land is designed to be on, the house respects the culture of the Saudi traditions by separating the public parts of the house from the private parts.

As in the previous case study, the Landform house was designed in a sustainable manner but is not considered affordable. Therefore, it is recommended to use the concepts of the Landform house, such as respecting the landform and incorporating gardens between open spaces of buildings, but to tailor the building to affordable for low- and middle-income families of Saudi Arabia. One method to achieve this is by reducing the land plot size and reducing the built-up area accordingly.

The Fence house and the Landform house were designed by ‘The Other Dada’ to use sustainable building materials such as low-VOC paints, no formaldehyde glues, locally sourced materials whenever possible, mineral wool insulation, concrete mixture including 30 per cent of Pozzolan material, and photocatalytic concrete. These building materials, in addition to the other methods and techniques used, increase the amount of energy saved, reducing the overall impact on the environment.

7.5 SUSTAINABLE CASE STUDY 3 ANALYSIS

The third case study is an apartment building in the city of Jeddah that was analysed by Taleb and Sharples (2011). Figure 7.10 shows the location of the project in its urban context in Jeddah. The building is considered new and occupies a total land area of 625 m^2,with a built floor area of 420 m^2.

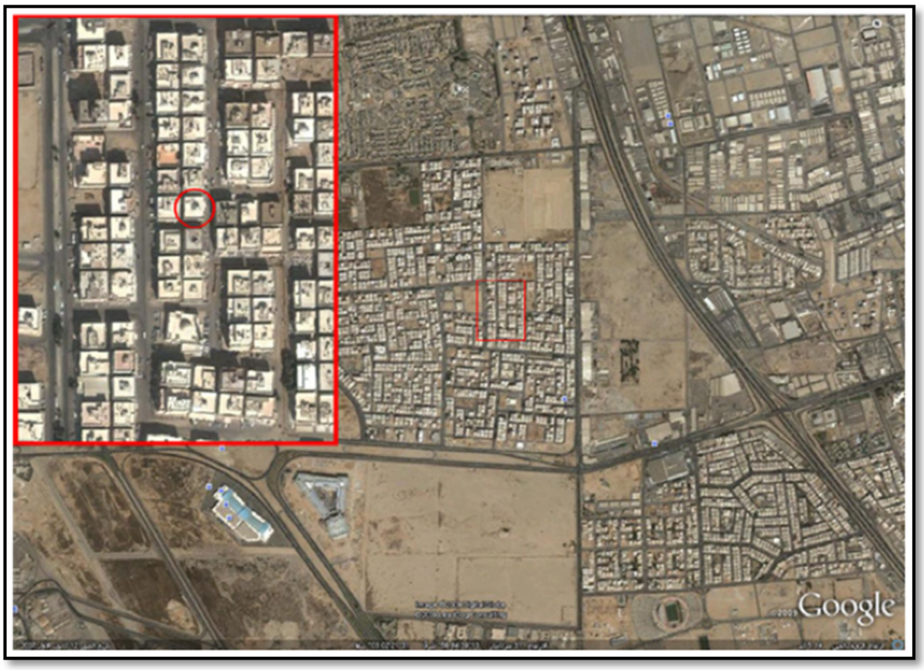

Figure 7.10. Case study 3 location in Jeddah (Taleb & Sharples, 2011).

This type of apartment building is typical of Saudi Arabia and provides a reasonable space for a small family that has a low or middle income. The apartment building consists of three floors and each floor has two apartments. Figure 7.11 shows the floor plans and elevations of the building. The building is analysed according to its energy use, water consumption, CO_2 emissions and building material as illustrated in Table 7.4.

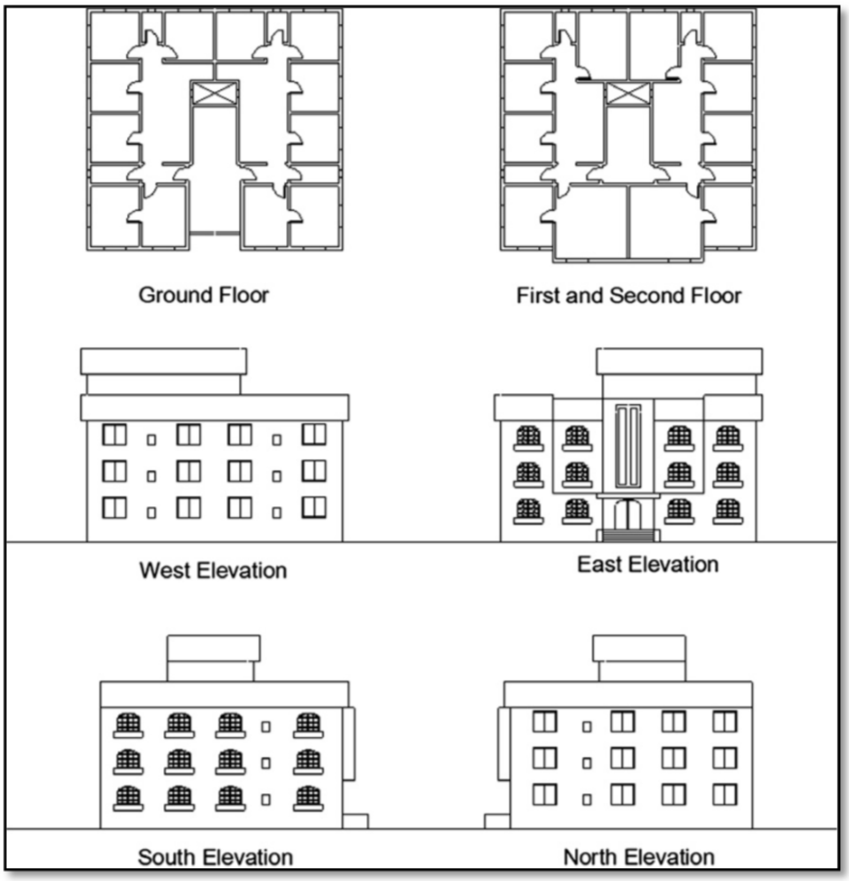

Figure 7.11. Floor plans and elevation of case study 3 (Taleb & Sharples, 2011).

Simple sustainability measures were taken to reduce energy and water consumption and the overall CO_2 emissions. To save on energy, improved thermal insulation panels were installed in the walls; these reduced the overall U-value, which resulted in less energy needed to cool the indoor environment. There was 100 mm-thick foam insulation installed in the wall gaps between the layers of interior and exterior walls, which reduced the heat penetration rate. Additionally, 100 mm-thick polyurethane insulation panels were installed in the roof, which also decreased heat penetration. With these simple modifications to traditional construction methods, the total energy savings, as illustrated in Table 7.4, are around 32 per cent per year. There is an additional 10 per cent that can be deducted from the overall energy consumption because the installed PV panels provide 10 per cent of the energy back into the grid.

Table 7.4

Case Study 3 Profile

Project		Apartment Building in Jeddah
Land Area		625 m^2
Built-up Area		420 m^2
Energy Consumption	Baseline Consumption	146,372 KWH/Year
	Post Sustainable Measures Consumption	98,992 KWH/Year
	Percentage Saved	32.40%
% of Renewable Energy From PV Panels		10%
Water Consumption	Baseline Consumption	498 LCD
	Post Sustainable Measures Consumption	276 LCD
	Percentage Saved	55.40%
CO_2 Emissions	Baseline Emissions	69,000 KG/Year
	Design Emissions	37,000 KG/Year
	Percentage Saved	53.60%

Water consumption levels in the apartment building were high, as is the case in almost all Saudi residential buildings. The overall annual water consumption level was around 498 lcd compared to an annual average water consumption level in Europe of 200 lcd. The water consumption levels are shown to be decreased by more than 55 per cent by simple measures such as a grey water system (which collects 90 per cent of the bath and shower waste in order to supply toilet cisterns), low-flow showerheads, low-flow tap aerators in the bathrooms and kitchens, dual-flush cisterns, and efficient washing machines. If these simple sustainability measures can be installed and used, then this would result in water conservation levels of over 1,458,000 L/year from one building.

In terms of the location of the case study and its relation to the neighbourhood, the building is in close proximity to four Masjids, a school, a service station and a playground. Additionally, the buildings located on the major streets near the case study have shops on the lower levels. This is because, as part of the municipal rules and regulations in Saudi Arabia, buildings located on major streets must allocate lower level sections of the building to retail. Thus, it is evident that the case study has more than five services within walking distance, which promotes sustainability, but only if the neighbourhood provides safe pedestrian access. Unfortunately, the neighbourhood does not provide safe pedestrian access to the nearby services. Because of lack of adequate pedestrian footpaths and safe crossings as discussed earlier in sections 3.2 and 3.3, more design effort is required. It is also evident from the location map (see Figure 7.12) that there is a huge Masjid covering a large area of land on the left side, which could have included other services such as government offices, a fire station and other much-needed services.

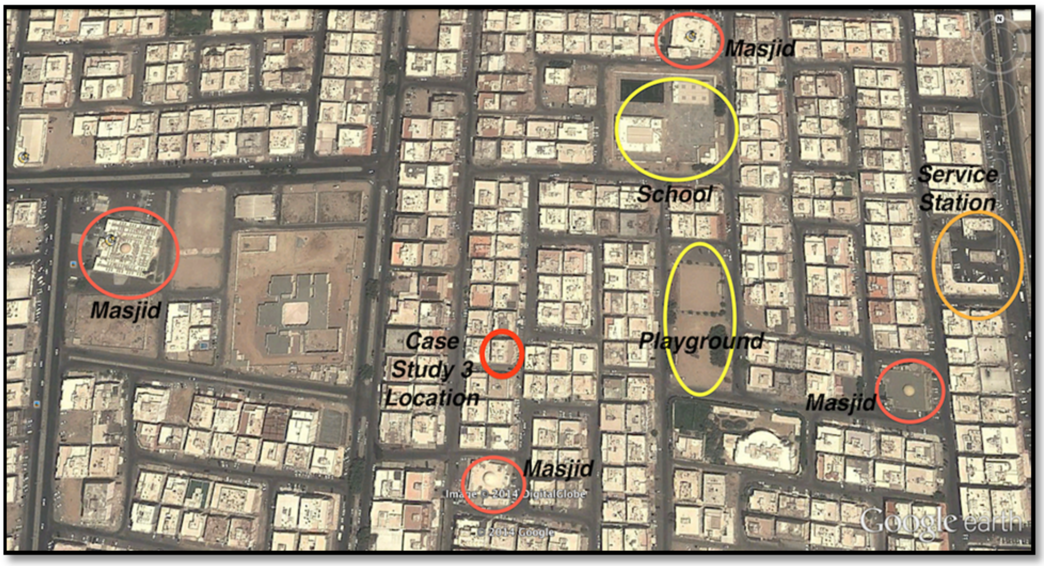

Figure 7.12. Case study 3 location in relation to the neighbourhood (Google Maps, 2014a).

In contrast with the Fence house and the Landform house, this case study is considered affordable for low- and middle-income families in Saudi Arabia, but the issue remains that sustainability has not been fully achieved in the design of the building. This is due to the location of the building and how unsafe it is to walk to close-by amenities such as the *Masjid* or the shops. Further, the aspect of privacy has not been considered fully and the design of the apartment building is a generic replica of Western apartment buildings, which are not suitable for the Saudi culture. Last, the courtyard design has not been incorporated, although it could have helped in achieving privacy in addition to having natural air ventilation flow through the rooms of the apartment. This could have been achieved if each apartment had an open area that resembles a courtyard, permitting daylight and natural ventilation to pass through the apartment.

7.6 DISCUSSION

From the case studies, it is evident that utilising sustainability measures, such as those reducing energy and water consumption and CO_2 emissions, is a must for the survival of Saudi Arabia's natural resources and environmental conservation on a global scale. It has been shown that the majority of energy consumed in residential buildings in Saudi Arabia, over 80 per cent, is due to cooling the indoor environment if the building is not insulated. Designing buildings that permit daylight and reduce direct sunlight will evidently reduce the cooling load and reduce the energy consumption overall. Selection of certain building materials that are environmentally friendly, such as insulating concrete, is crucial to reducing the heat island effect. Design elements can be largely divided into architectural technologies (a passive method) and equipment-related approaches (an active method). The use of the two architectural design methods can help reduce the overall consumption of energy and help improve the environment.

The amount of energy and water consumption and CO_2 emissions in the three case studies are shown in tables 7.2, 7.3 and 7.4. Energy saving in the Landform house reached 27 per cent when sustainability measures were incorporated into the design. Water consumption saving reached more than 55 per cent in the apartment building case study, which means that water consumption can be greatly reduced and high saving percentages can be easily achieved if sustainable methods are used. CO_2 emissions can also be greatly reduced, as indicated by the apartment building case study, which revealed a CO_2 emission reduction of more than 53 per cent, which equates to 32,000 kg per year.

The case studies have presented a considerable amount of reduction in energy and water consumption and CO_2 emissions. Further, they have also proved the value of PV panels, which produced energy from 8 per cent to an astonishing 17 per cent of the household's needs. These PV panels, such as in the Landform house, are no longer treated as an add-on feature to the building, but are integrated into the design of the roof of the building, where four roofs have PV panels that are facing the south and are at an optimal 25-degree slope for maximum energy generation.

What is more, the Fence and Landform houses have used native landscaping that helps reduce the overall amount of water irrigation. For example, the Landform house uses 4000 L/day of grey water for irrigation of palm trees and Tamarix trees that are planted on-site. Additionally, the use of grey water is through efficient drip irrigation. It diverts wastewater from the municipal sewer, treats it and releases it into the ground, which reduces the load on the city's infrastructure and reduces the demand of the building sector.

Figure 7.2 shows that the remarkable increase in cooling loads, reaching more than 81 per cent due to lack of insulation, can put a heavy burden on energy production in Saudi Arabia. This is because there are no strict laws to bind builders to use a certain type of insulation that can contribute dramatically in the overall conservation of energy. In contrast, the same housing unit registered a reduction in cooling load simply by adding appropriate insulation (see Figure 7.3). Energy consumption can also be reduced by 30 per cent if high-efficiency lighting technologies are installed in the house, which are able to recoup their cost in five years' time. From this data, it is evidently crucial that the Saudi Government administers strict laws concerning the types of insulation that should be used. Further laws have to be applied to promote the use of sustainable methods to achieve an overall reduction in consumption of energy and water.

Saudi Arabia has the third-highest average amount of water consumption in the world, according to the KAUST Industry Collaboration Program (2013), after the US and Canada, amounting to 325 L/capita/day. An amount of 288 L/capita/day of grey water can easily be recyclable, which also computes to a total discharge of 89 per cent of total consumption. This water consumption level is extremely high when taking into account that Saudi Arabia is considered a water-scarce country with an annual renewable water resource of 86.45 m^3 (The World Bank, 2013). The easiest way to reduce water consumption is by the installation of a water-saving device, but this incurs an initial cost burden on the consumer that can be waived if the Government provides subsidies or other benefits in consideration of the long-term cost savings and water conservation amounts. In the baseline water consumption case study undertaken by the KAUST Industry Collaboration Program (2013), showers and faucets accounted for 43 per cent and 30 per cent of water consumption, respectively, considerably higher than for other outlets. This suggests that by installing a grey water collection system, water can be 100 per cent reused for toilets and selected cleaning.

Lessons can be learned from the apartment building case study, where it was evident that there is potential to have one large *Masjid* that has all the necessary needs of the local neighbourhood in one location. The *Masjid* is within close proximity to the case study, but the local services and needs of that neighbourhood are not accessible and the use of cars is a necessity for the residents to obtain their needs. Further, the nearby services have no safe pedestrian or pedestrian-friendly access, which furthers the need to use cars for the safety of the residents. Redesigning the neighbourhood to be sustainable is manageable and can be achieved if Saudi stakeholders introduce new regulations that can be sustainable and provide safety for the residents. In conclusion, Table 7.5 illustrates the elements that have been achieved by the three case studies and the elements that have not been achieved in terms of sustainability and affordability.

Table 7.5

Comparison between the Three Case Studies

Category	Case Study 1 The Fence House	Case Study 2 The Landform House	Case Study 3 Jeddah apartment Building
Energy Consumption	✓	✓	✓
Water Consumption	✓	✓	✓
CO_2 Emissions	✓	✓	✓
Cultural Aspects (Privacy, Courtyard, Segregation)	✓	✓	
Building Material	✓	✓	✓
Affordability			✓

7.7 SUMMARY

As sustainability in housing design in Saudi Arabia is a relatively new concept, it was not easy to obtain possible case studies for analysis. However, despite this difficulty, three sustainable housing projects were chosen, along with a non-sustainable housing project in Saudi Arabia, to enable this analysis to proceed. The sustainable case studies were analysed and linked with the literature review and the previous two data collection methods based on environmental factors, mainly energy and water consumption and CO_2 emission reduction. Economic factors were analysed and linked by examining the conservation of energy and water consumption, which reduced the overall cost, and the utilisation of renewable energy sources. Finally, socio-cultural factors were analysed and linked through the design of the neighbourhood, which should meet the needs of the conservative Islamic culture by providing close proximity to a *Masjid* with all the neighbourhood's requirements on-site.

It is evident that the use of sustainable construction methods in Saudi Arabia is a necessity for the survival of the country's natural resources. The Saudi Government should promote the use of sustainable technologies, such as water-saving devices in faucets, showerheads and kitchen sinks, where consumption reduction could reach up to 55 per cent. It is also evident that an overall reduction in energy consumption could reach more than 50 per cent. Therefore, it is imperative that energy saving techniques are applied in housing in Saudi Arabia, for the sake of conservation as well as economics. Additionally, redesigning the neighbourhood to meet the local and cultural needs is a necessity for economics as well as the prevention of increasing CO_2 emissions.

Saudi Arabia is making decisive moves towards implementing sustainable and green construction methods, but more data are needed to convince the public and the Government of the necessity of applying these methods now while the country is still under rapid development. It is also recommended that Saudi stakeholders become involved to reduce bureaucracy and hasten the application of sustainability to current and future construction. Finally, the Saudi Government should mandate new laws to reduce the overall consumption of energy and water to decrease the depletion of natural resources.

Chapter 8: Discussion

8.1 INTRODUCTION

This thesis has identified the key stakeholders in the Saudi housing construction industry. This study has also addressed the CSFs (or enablers) and barriers facing the application of sustainability to housing construction and construction in Saudi Arabia, and the adaptation of the unique conservative Islamic culture of Saudi Arabia into the design of sustainable housing. This chapter now discusses the findings from the primary and secondary data and links them to the research questions and objectives. The aim is to synthesise the conclusions regarding the research gap and the findings from the data collected to provide answers to the research questions and achieve the research objectives. In this section, the research questions are discussed separately and validated with answers from the primary and secondary data of this research.

8.2 CURRENT UNDERSTANDING OF KEY STAKEHOLDERS ON SUSTAINABLE HOUSING

As discussed in the literature review, (Assaf et al., 2010; Mandeli, 2008; Mathur et al., 2008; Reffat, 2004), the key stakeholders involved in this research come from private, academic and government sectors of the Saudi construction industry. This thesis began with a preliminary survey, which was distributed to nearly 700 participants. The results indicated that the Saudi public is unaware of sustainability and, particularly, sustainable housing. The study was published (Susilawati & Al Surf, 2011) and showed that over 52 per cent of the participants have not heard of the term ‘sustainable housing’. It was concluded that public awareness is one of the key obstacles in the development of sustainable housing in Saudi Arabia.

This finding has been validated by several researchers who attribute this lack of awareness to three main reasons. The first reason is that it is difficult for the public to understand the terminology due to their being numerous variations with the same meaning, which confuses the public (Eden, 2000; Miranda & Marulanda, 2001; Pett, 2004; Reffat, 2004; Salama, 2006; Susilawati & Al Surf, 2011). The second reason is lack of public awareness campaigns launched by Saudi Government bodies that should educate the public on the benefits of applying sustainability measures to housing projects in Saudi Arabia. Participants from the public awareness survey agreed that the Saudi public should be educated. Participants said:

> It has to be accompanied with a change in people’s thinking.
>
> I wish houses could be built this way in Saudi Arabia, and I also wish it was mandatory and enforced and an essential part of the forthcoming SBC. However, before that, awareness is necessary to convince owners to go that way.

Therefore, the public needs to be educated on the benefits of applying sustainability to housing construction by the launching of continuous awareness campaigns through local media outlets and in schools and universities. This would result in the concept of sustainability being more widely applied and more accepted if the Saudi Government chooses to mandate its application through the SBC in the future.

The third reason is lack of stakeholder involvement or interest in developing and pursuing the application of sustainability to housing in Saudi Arabia, as discussed in the literature (Assaf et al., 2010; CA News Network, 2013a; Mandeli, 2008; Mathur et al., 2008). Further, respondents in the public awareness survey agreed that the Saudi stakeholders should be more involved and mandate the use of sustainable methods through the SBC. Participants stated:

> I think that the idea of sustainable buildings should not remain an idea; it must be included in the building code and applied gradually so as not to become a choice but a necessity for the design and construction.

> It should be promoted by all involved parties: government agencies, designers, contractors, suppliers, as well as the local press.

Experts from the Saudi construction industry were the targeted participants for this research. In the first data collection method, semi-structured interviews were conducted with nine professionals who gave their thoughts and ideas on the challenges facing the application of sustainability to housing in Saudi Arabia. The selected participants for the interviews were all knowledgeable on sustainable housing, but they differed in terms of actual practice in being part of a sustainable project.

8.2.1 Semi-Structured Interview Discussion

The thematic analysis of the semi-structured interview provided an answer to the first research question. The participants' responses showed that six of the nine chosen stakeholders have a great understanding of sustainability and agreed that sustainable development should consider the effect of any construction development on the environment. This result of stakeholder awareness supports the findings from the literature and the public awareness survey and demonstrates that stakeholder awareness and current understanding helps the development and application of sustainability to housing construction in Saudi Arabia.

Moreover, the stakeholders responded to the economic aspect of sustainability. Four respondents agreed on the importance of the economic aspect of sustainability and that it should minimise the overall cost of the development. This result can be achieved if building materials are sourced from local sources, and three participants agreed that any sustainable development should be built from local resources or building materials. The conservation of energy and the use of renewable energy are related, thus five participants reported that energy conservation and the use of renewable energy is a must in any sustainable development. The final theme derived from the semi-structured interview was affordability. Three participants reported that any sustainable development should be affordable.

The responses of the stakeholders in the semi-structured interview to the socio-cultural aspect of sustainability was interesting in that three respondents agreed that the local culture should be respected. This low level of response is the outcome of the remaining respondents disagreeing that vernacular architectural design style should be incorporated in modern housing designs. The results showed that all respondents agreed on the concept behind vernacular architectural design elements, such as optimising passive cooling by natural ventilation techniques. However, some of the participants disapproved of the use of vernacular architectural elements such as the Mashrabiya because they are outdated. This is also validated by the responses of the participants when they pointed out several sustainability parameters derived from the sustainability definition, which included the use of daylight, natural ventilation and local building materials. These sustainability parameters that link to the socio-cultural aspect of sustainability have been achieved through vernacular architectural designs, and the concepts behind them can be incorporated into modern day housing designs. Therefore, based on these findings, this research recommends the incorporation of the concepts behind vernacular architectural elements, such as the Mashrabiya and the courtyard, into new modern Saudi housing designs.

8.2.2 Delphi Method Discussion

The results from the semi-structured interview formulated the Delphi round questions. The first question in the first Delphi round was to obtain an understanding of the stakeholders definition of what is sustainability. The results showed that the respondents ranked the following elements to be of high value:

- environmentally friendly
- low-cost, long-term maintenance.

The highest ranked element, ‘environmentally friendly’, corresponds to the environmental aspect of sustainability. This result indicates that the selected stakeholders who participated in the Delphi rounds consider having an environmentally friendly house as the highest priority. This concurs with the literature review, public awareness survey and the semi-structured interviews. Having stakeholders consider the environment as the highest priority is a positive reaction, since the arid harsh environment of Saudi Arabia should be incorporated in the design of sustainable housing in the country. Accordingly, this research concludes that careful consideration of the surrounding environment of Saudi houses is vital to achieving sustainability.

The second highest ranked element chosen by the stakeholders was related to the economic aspect of sustainability. This also concurs with the outcomes from the literature review, the public awareness survey and the semi-structured interviews. Incorporating the harsh arid climate of Saudi Arabia into the design of a house will minimise the overall operational cost as well as the long-term maintenance cost. Techniques to achieve this have been discussed in the literature review, such as the orientation of the house and location of the openings of the house, windows and doors to minimise the use of cooling systems. Therefore, according to the stakeholders, low-cost, long-term maintenance needs to be considered in housing designs in KDSA for future housing projects.

The following elements from the definition of sustainability were ranked as medium value in the first round, but participants in the second round re-ranked them as high value:

- energy efficiency
- employing (absorbing) the local weather
- affordable to the consumer
- suitable for the local environment and cultures
- building from local materials.

This re-ranking further emphasises that the environment and the economic aspects of sustainability must be considered in the design of housing in Saudi Arabia. The stakeholders also added and re-ranked from medium to high the third aspect of sustainability, which is the socio-cultural dimension, and validated that the local culture has to be considered and respected, as discussed in the literature review and the semi-structured interviews. To conclude, it is recommended that the local Saudi environmental, economic and unique socio-cultural aspects be considered in future housing construction projects for the successful application and development of sustainability in the country.

8.2.3 Case Study Analysis Discussion

The first research question was also answered through the three case studies, which validated their successful selection. The projects were designed following sustainability parameters and incorporated the unique conservative Islamic culture of Saudi Arabia in some form or another. A great deal of understanding from the stakeholders of the case studies achieved the first research objective. This was evident through the design and application of sustainability measures throughout the three case studies. For example, the designer of the Fence house and the Landform house incorporated renewable energy technologies in the two houses, which demonstrated that the designer has a sound understanding of how to utilise sustainable technologies.

The case studies, however, differed when it came to affordability. It is optimal to have a sustainable house affordable, as discussed in the literature review (Affordable House Co., 2012; Milligan & Gilmour, 2012; Opoku & Abdul-Muhmin, 2010; Smith, 2012), but having a house built to sustainable standards for a wealthy family who is willing to pay for a luxurious villa style house is a personal choice. Nevertheless, sustainability and affordability must be the main focus for future housing construction projects and several case studies can be studied throughout the Arab world and globally to support this.

To conclude the discussion of the results of the first research question, the stakeholders chosen according to their level of expertise and involvement in sustainable development in the country showed a great understanding of what sustainability is and what is involved in sustainable housing. Their answers resulted in fulfilling the three pillars of sustainability, where all participants agreed that a sustainable house needs to be environmentally friendly. That is, it should be built from local resources, respect the cultural norms of the society, reduce the overall cost of the building, conserve energy, utilise natural renewable resources for energy provision of the building and be affordable.

8.3 BARRIERS AND CSFS (ENABLERS) FOR THE DEVELOPMENT OF SUSTAINABLE HOUSING

To answer this research question, the responses from the three data sets in this thesis are discussed here in two parts: barriers and CSFs.

8.3.1 Barriers Discussion

The barriers that were distilled from the literature review include: lack of public awareness, lack of government support, lack of stakeholder interest, lack of affordable land for developing affordable sustainable housing, the Westernisation of modern Saudi houses that neglect the cultural norms of the occupants, and finally, lack of incentives to use sustainable construction methods such as the use of renewable energy sources. The participants interviewed concur with the outcomes of the literature review (Assaf et al., 2010; Business Monitor International, 2011; Colvin, 2006; Eden, 2000; Karam, 2010; Miranda & Marulanda, 2001; Opoku & Abdul-Muhmin, 2010; Reffat, 2004; Savard et al., 2010; Taleb & Sharples, 2011; Timewell, 2011; Watson, 2005), and listed the following barriers:

- Lack of public awareness of the positives of sustainable housing
- Lack of stakeholder interest in applying sustainable housing
- Shortage in sustainable construction material
- High cost of sustainable housing and long period of return of investment.
- Low levels of investment in sustainable housing
- Lack of alternative designs of housing and focusing only on the villa typology
- Lack of awareness from designing firms of how to design sustainable housing.

The responses of the interviewees differed according to those who worked in sustainable projects and those who had not, as shown in Table 5.6. The former selected more barriers than the latter, indicating the importance of experience. Even though all stakeholders who participated in the semi-structured interviews are knowledgeable on the subject being investigated, the application of that knowledge proved to make a difference when asked to list any barriers. Therefore, it is concluded that Saudi housing construction stakeholders should be more involved in the construction process. This will help them to apply their knowledge, understand the barriers that might face future housing construction projects and prevent them.

The responses from the stakeholders in the semi-structured interview can be further broken down according to the three aspects of sustainability being investigated, as well as the application challenge. The application barriers are evident through the lack of stakeholder interest in applying sustainability measures to housing projects, and additionally through the lack of public awareness. What is more alarming is that design firms have limited knowledge on how to design sustainable houses, as stated by a few of the stakeholders. This creates further complications in the successful development and application of sustainability to housing in the country.

Environmental barriers can be found in the shortage of sustainable construction material and lack of alternative designs that do not copy Westernised villa typologies that neglect the local environment. Economic barriers are evident in the high cost of building sustainable houses and the low level of investments in this type of construction. Participants agreed that there is a lack of support from the Government and that the loans provided by the Government are not enough due to the high prices of the lands that are normally large in size and more than what the Saudi family requires. Socio-cultural barriers are seen thorough the lack of awareness of design firms of the local socio-cultural needs and through the lack of public awareness of how to incorporate their needs in modern housing designs. This can also be seen in one of the participant's comments as follows:

> The SBC misses out on fitting with the Saudi lifestyle at several stages. At the management code level: building preparation and proper definition. At the construction level: overcrowding spaces/ isles/ exits…

Additionally, participants viewed the use of the fence design around the house as alien to the unique conservative Saudi culture, as it was adapted from Western architectural designs and applied directly to the Saudi community. The purpose might be to achieve privacy, but the method is viewed as incorrect. This can be remedied through the use of courtyard designs similar to the vernacular architectural style but more modern. Further, participants suggested the use of clear-story windows in the outer perimeter rooms to achieve privacy and yet provide the desired daylight and ventilation as well. Validation of these conclusions can be seen in the following stakeholder comments:

> The design of the house can achieve privacy in a sustainable way but it does not have to be in the form of a fenced villa.
>
> Privacy can be achieved through employment of the Mashrabiya concept, provision of clear-story fenestration along the room walls instead of typical windows, or simply through designing the house with an introverted concept (looking inside to a courtyard).
>
> The task is in the hand of designers and they can change the current 'castle' system to reach elegant and more pleasant residential typologies that belong to the Saudi lifestyle and land.

The level of agreement on the barriers examined in the first Delphi round have also varied. Most of the 47 participants ranked lack of public awareness of the benefits of sustainable housing to be of high value. Table 6.5 shows the level of variation on the following barriers:

1. Lack of public awareness of the benefits of sustainable housing (High)
2. Lack of key stakeholders' interest in applying sustainable housing (Medium)
3. Low levels of investment in sustainable housing (Medium)
4. Lack of financial incentives (subsidies, insurance discounts, bank loans, etc.) (Medium)
5. Lack of awareness from designing firms of how to design viable sustainable housing (Medium)
6. Lack of government support (guidelines, building codes) (Medium)

7. High initial cost of sustainable housing (Medium)
8. Lack of alternative designs of housing (Medium)
9. Shortage of sustainable construction materials (Low)
10. Long period of return of investment (payback period) (Low).

Once again, lack of public awareness seems to be of high value and reaches high agreement between stakeholders. This high level of agreement indicates that educating the public is paramount to the successful development and application of sustainability to housing construction in Saudi Arabia. Lack of public awareness consequently is the result of other barriers, such as the lack of availability of sustainable construction materials. The public is unaware of the available sustainable construction materials. Several stakeholders have indicated that there are sustainable construction materials in the market, but the problem lies in the lack of awareness from the public of its availability.

The second highest ranked barrier, even though it is ranked as medium, is lack of stakeholders' interest in applying sustainable construction methods to housing projects in Saudi Arabia. This barrier is linked to the lack of knowledge of the public on the available sustainable construction materials, due to the lack of available incentives provided by the Saudi Government to the construction industry stakeholders. Hence, for housing construction stakeholders to become more involved and be interested in developing and applying sustainable housing, there needs to be cooperation between the Government and the stakeholders. The Government's role is to regulate the building laws and codes of sustainable housing and provide incentive programmes and schemes, whereas the stakeholders provide the construction materials to the public and educate them accordingly.

The results from the second Delphi round correspond with the results from the first Delphi round and the previous data collection methods. The following barriers reached consensus with high value ranking:

- Lack of public awareness of the benefits of sustainable housing
- Lack of financial incentives (subsidies, insurance discounts, bank loans, etc.).

The main outcome from all of the data collection methods is that lack of public awareness seems to be the most important barrier from the perspective of the participating stakeholders. This main barrier creates a vicious cycle beginning with the public not being aware of the benefits of having sustainable housing projects. This leads to the stakeholders not having interest in providing sustainable construction material and sustainable designs. Finally, this leads to the Government not mandating new laws to apply sustainable construction methods on housing projects in Saudi Arabia.

Henceforth, it is recommended that the Saudi Government starts by mandating the use of the SBC on all current and future housing projects at least to the minimum standards. Then the SBCs needs to be amended to provide sustainable regulations alongside non-sustainable regulations. After that, incentive programmes and schemes need to be developed by the Government to provide to the willing developers and stakeholders who will build sustainable housing projects. Then, the Saudi housing construction stakeholders will need to develop new housing designs that are sustainable and use sustainable construction materials and be awarded with incentives by the Government for using sustainable construction methods. Finally, the public must be approached and educated on the benefits of building sustainable houses that can be built in accordance with the local laws and regulations, using local sustainable construction materials, and where incentives can be given to whomever builds or buys these types of houses.

The participants changed the ranking of the following barriers from a medium value to a high value, so they are ranked as high:

- Low levels of investment in sustainable housing
- High initial cost of sustainable housing.

This re-ranking validates the importance of stakeholders needing to invest more in sustainable housing projects and becoming involved in reducing the initial cost of these types of projects. This will help promote the use of sustainable construction methods in future housing projects, which will eventually reduce the overall consumption of electricity and water and save the scarce natural resources of the country.

The following barrier reached consensus with low level ranking:

- Shortage of sustainable construction materials.

This low level of consensus indicates that some stakeholders know that there are sustainable construction materials in the market, but due to lack of public awareness, this is still considered a barrier. Therefore, educating the public on the available sustainable construction materials is vital to the successful development and construction of future sustainable housing projects.

- The case studies have also faced barriers. The designer of the first two case studies listed the following barriers that faced the Fence house and the Landform house:
- the fact of having the fence (which is obligatory) hinders the visual connection and community aspect of sustainable neighbourhoods

- the lack of recycling facilities
- the lack of adequate public transportation
- the lack of bicycle and pedestrian lanes
- the lack of awareness of local contractors (working on smaller-scale projects) about sustainability practices
- the fuel subsidies which lead to cheap and highly polluting energy
- the lack of net-metering measures that would allow us to feed our on-site generated renewable energy back to the grid.

The above-mentioned barriers accentuate what has been discussed earlier as the result from the previous data collection methods. The barriers revolve around the four challenges facing the application of sustainability to housing construction projects in Saudi Arabia. Lack of public transportation and lack of bicycle and pedestrian lanes, for example, are related to the environmental aspect of sustainability. The lack of such services and facilities will cause the continuous and increasing use of cars that will further pollute the environment. The use of cars can be reduced immensely if new neighbourhoods are designed using an urban village concept that adopts the traditional Saudi neighbourhood. The traditional Saudi neighbourhood, as discussed in the literature review, was designed in a radial form where the central point was a Masjid that had all the amenities and facilities the local neighbourhood needed. It is therefore recommended that the planning of unnecessary streets be avoided and the concept of an Islamic urban village be adopted in future neighbourhood developments.

The fuel subsides provided by the Saudi Government lead to the overconsumptive behaviour of the Saudi population of energy and water, which is directly related to the application challenges. Additionally, lack of net-metering measures that would allow the designer and developer to feed their on-site generated renewable energy back to the grid is also related to the application challenge. Lack of awareness of local contractors is again an application challenge that can be eliminated in future housing projects. These barriers can be alleviated if support from the Government is provided; new sustainability laws and rating systems need to be mandated for the successful development and application of sustainability to housing projects in the country.

In terms of the economic aspect of sustainability, the fuel subsidies provided by the Saudi Government that have led to the overconsumptive behaviour of the Saudi population of energy and water contribute immensely to the economic barrier of sustainability. Further, the lack of provision of recycling facilities hastens the overfilling of landfills with recyclable rubbish. This leads to producing more recyclable products and materials that will not be recycled, which is wasteful of both time and money due to lack of recycling facilities.

The socio-cultural aspect of sustainability has also been challenged in the case studies. The designer of the Fence house and the Landform house emphasised the problem of the fence in the Fence house mainly because it hinders the visual connection and community aspect of sustainable neighbourhoods. The erection of fences around houses in Saudi Arabia is a means of achieving privacy, but that does not mean that they are the right way to provide privacy for residents. Since these fences were adapted from Western designs, they have neglected other aspects and caused more challenges than solutions, as stated by the designer of the Fence and Landform houses. Further, the third case study, which was the apartment building in Jeddah, also had some socio-cultural challenges. The apartment building was built in close proximity to adjacent buildings and the windows are situated in a place that does not provide the desired privacy for its inhabitants. Therefore, it is vital to incorporate the unique Saudi culture into the design of future sustainable housing projects in order to meet the needs of their inhabitants.

To summarise, lack of public awareness is the barrier that reached the highest consensus. This barrier causes several other barriers to occur, such as the conceptualisation that sustainable housing has a high initial construction cost. While the literature indicated that sustainable housing construction does cost a little more than normal housing construction initially, around 12 per cent more, it can save on the overall cost of the house lifecycle by 10 per cent compared to non-sustainable housing. Another cause of lack of public awareness that participants reached consensus on was ranking the shortage of sustainable construction material as low value. This is a direct consequence of lack of knowledge of the availability of sustainable construction material in the Saudi construction materials market. Thus, it is vital that the Saudi Government and other key Saudi stakeholders take initiative and prioritise educating the public on the benefits of sustainable housing that can be affordable and saves on the general running cost, in addition to other environmental and socio-cultural benefits. Figure 8.1 illustrates the challenges facing sustainable housing in Saudi Arabia according to the four aspects required to achieve sustainability that were discussed earlier: economic, environmental, socio-cultural and application challenges.

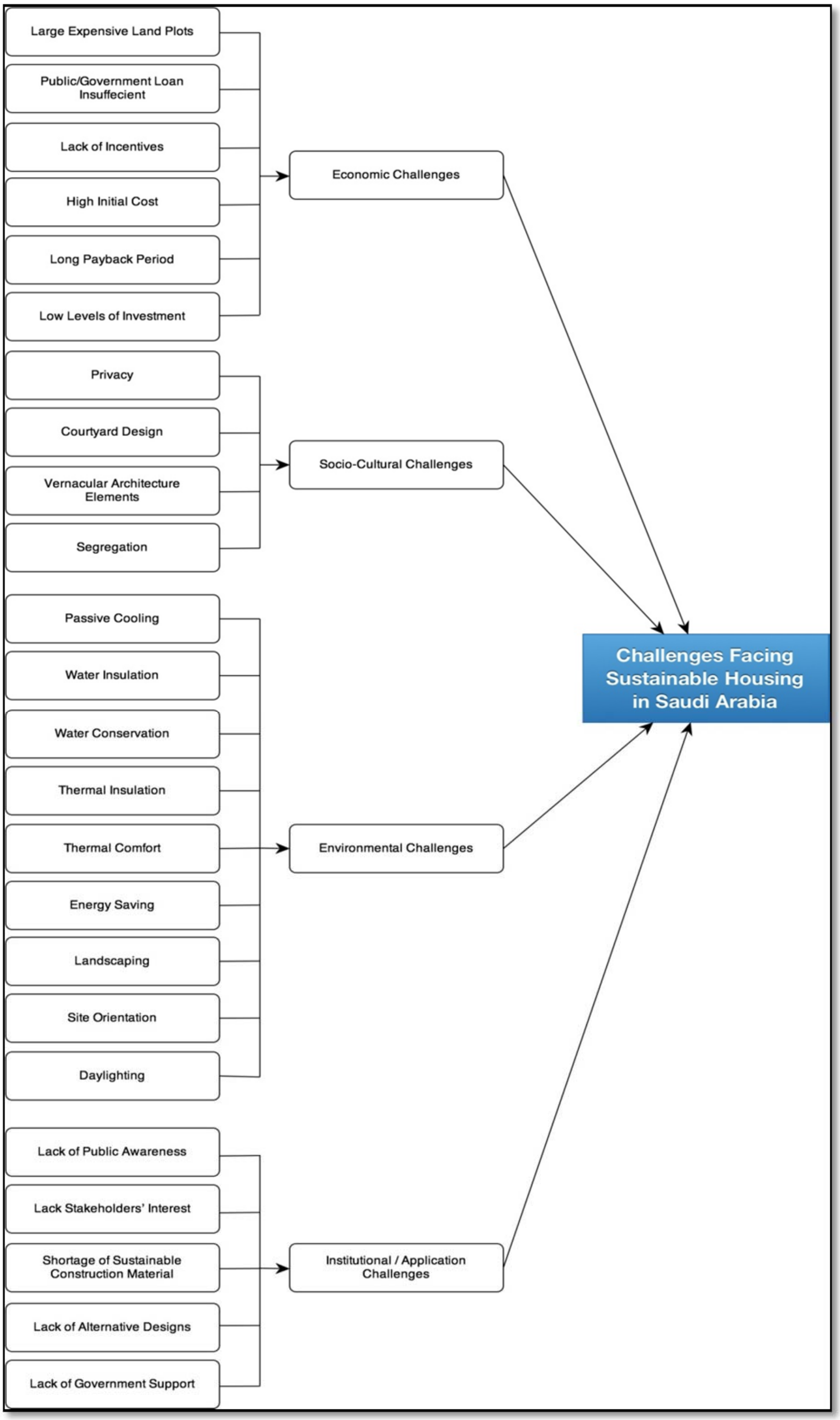

Figure 8.1. The challenges facing sustainable housing in Saudi Arabia.

8.3.2 CSFs (Enablers) Discussion

The literature review argued that one of the crucial CSFs is the involvement and collaboration of all stakeholders to implement sustainability in the housing construction industry in Saudi Arabia (Assaf et al., 2010; CA News Network, 2013a, 2013b; Eden, 2000; Mandeli, 2008; Miranda & Marulanda, 2001; Reffat, 2004). Another CSF from the literature review is the incorporation of the cultural and traditional norms of the Saudi public into the design of sustainable housing (Abu-Ghazzeh, 1996; Abu-Ghazzeh, 1997; Al Naim & Mahmud, 2007; Al Shaali, 2002; Al Hazmi & Nyland, 2010; Eben Saleh, 1998; El-Shorbagy, 2010; Hamdy, 2000; Jepson, 2001; Mabrouk, 2006; Mubarak, 1999; North & Tripp, 2009; Samuels, 2010; Shihabi, 2004; Swanson, 1996; Taleb & Sharples, 2011; Weber & Yannas, 2014).

Findings of the CSFs and barriers from the literature review were carried through to the interviews that were conducted with nine Saudi stakeholders, who also identified several CSFs, as illustrated in Table 5.7. Table 5.7 shows that participants who worked with sustainable projects selected five or more CSFs, while participants who did not have any interaction with sustainable projects selected less. This indicates that exposure to sustainable projects greatly affects stakeholders' judgment of CSFs and how they apply to sustainability in Saudi housing. A notable result from Table 5.7 is that the utilisation of solar energy is one of the least selected CSFs. This may be due to the high cost of installing solar panels as well as the high maintenance cost of such a system. It may also be due to the fuel subsidies the Saudi Government is providing, as discussed earlier. As one of the participants noted, it is much cheaper to burn fossil fuels than install solar panels in both the short term and long term.

The following points are also derived from the participants' comments from the interviews:

- educate all designing firms on the SBC
- take advantage of local media to create public awareness of SBC.
- enforce new housing projects to use the SBC
- renovate old housing projects to reach the minimum level of the SBC
- the SBC should address and solve local environmental problems.

These points revolve around the four sustainability challenges discussed throughout this thesis. The environmental CSFs elaborated upon by the interviewees are highlighted through the incorporation of new laws that mandate the respect of the local harsh arid climate in the SBC. This will serve to minimise the overconsumption of energy through the reduction of continuous use of air conditioners in hot areas of the Kingdom. Moreover, the stakeholders are aware of the environmental impacts of overconsuming the scarce natural resources of the country, but they are reluctant to use alternative energy-producing measures due to the Government subsidies of fuels. It is therefore recommended that the Saudi stakeholders take initiative and introduce new affordable and sustainable energy-producing technologies that can be installed alongside the traditional energy metering and producing equipment. This will help residents with low and middle incomes to opt to use these technologies, which in the long term will help reduce the overall emissions of CO_2 from traditional fossil burning energy plants. This outcome is reinforced by one of the stakeholders' comments:

> Saudi Arabia is one of many countries that have sun exposure almost all year round, and the housing sector consumes huge amounts of non-renewable energy. So, for this reason, solar energy is a needed

> alternative opposed to the conventional energy of burning fossil fuels.

The economic CSFs pointed out by the interviewees emphasise the need to reduce the soaring land prices evident in the current Saudi real estate market. As one participant recommended:

> Create new laws that help reduce the soaring property prices, find some other privileged system for the real estate that takes into account the needs of people who are new house buyers, and impose strict systems to get buildings distinct, healthy and at a reasonable cost.

Interviewees indicated socio-cultural CSFs in agreeing that the current 'castle' design does not meet with the unique conservative Saudi culture; there needs to be a change in the ideas of design that incorporate the needs of the local community. It is therefore recommended that stakeholders who are in decision-making positions mandate the incorporation of the unique conservative Islamic Saudi culture into the design of new houses. House should reflect on what can be achieved in vernacular designs and not mimic Western designs that do not meet the local community's needs.

The CSFs that were examined in the Delphi rounds were based on the responses of the interview participants. Nine CSFs were identified:

- educating firms on how to design sustainable housing
- enlightening the public on the advantages of sustainable housing
- implementing new laws that enforce the utilisation of sustainable methods to housing construction

- applying sustainable construction methods that meet the environmental comfort needs of residents
- the provision by the Saudi Government of affordable sustainable housing units for low- and middle-income families
- green energy should be the main energy source of sustainable housing in Saudi Arabia, such as solar energy
- enforcing rainwater collection and grey water treatment systems on every housing project, new or old
- residents in any Saudi neighbourhood should have all basic needs within walking distance—such as a mosque, a shopping centre, and access to government offices
- the Saudi Government should provide financial incentives (subsidies) to whoever applies sustainable construction methods to their house.

From the responses of the first Delphi round, where 47 Saudi stakeholders ranked the CSFs to be of high, medium or low values, the following CSFs were ranked as high according to the responses' mean cut-off scores:

- educating the public on the advantages of sustainable housing
- applying sustainable construction methods that meet the environmental comfort needs of residents
- educating firms on how to design sustainable housing
- the Saudi Government should provide financial incentives (subsidies) to whoever applies sustainable construction methods to their house
- implementing new laws that enforce the utilisation of sustainable methods to housing construction.

It is promising to see that the highest CSF according to the stakeholders is to educate the public on the advantages of applying sustainability to housing construction. This is a direct result of the highest barrier identified earlier, which is lack of awareness of the public on this issue. Further, the stakeholders took the sustainability concept and provided CSFs that comply with the four challenges discussed in this thesis. The environmental CSFs are validated by the high scores of the responses to the first Delphi round question, which was related to the sustainability definition. The stakeholders defined a sustainable house to be environmentally friendly and employing (absorbing) the local weather; these are the two highest-scored elements from the sustainability definition. Further, natural lighting, natural ventilation, thermal comfort, site orientation, indoor air quality, and passive cooling were also ranked of high value in two further questions from the first Delphi round, questions 2 and 7. These indicate that the stakeholders value the environmental aspect of sustainability and have detailed their responses on what should be considered in the design of sustainable housing projects in Saudi Arabia.

Economic CSFs that were ranked as high in the first Delphi round indicate that the stakeholders consider that sustainability cannot be achieved in Saudi Arabia unless these factors are met. These include low-cost, long-term maintenance, energy efficiency, the provision of financial incentives by the Saudi Government, cost saving, water conservation, reducing land prices with the help of the Saudi Government, and the construction of affordable sustainable housing projects by the Government. Henceforth, it is recommended that the Saudi Government heavily intervenes in the development of sustainable housing projects in the country and mandates new laws that reduce the price of land. Further, it must provide incentives for developers and residents who apply or use sustainable construction methods.

Socio-cultural CSFs mainly evolve around the adaptation of the unique conservative Islamic culture of Saudi Arabia. The main focus of the responses of the first Delphi round is on achieving privacy through several methods. This can be achieved through methods such as the use of Mashrabiyas or the design of inner courtyards and limiting the outer perimeter windows. Two elements that were ranked as high in the Saudi culture question elaborate on the important use of the courtyard design and how the courtyard design does not only provide privacy, but has other social benefits where it can help provide a private gathering area for the whole family and can provide pleasant environmental conditions throughout the year if designed properly, as discussed in the literature review. Although some participants thought that the incorporation of vernacular architectural features is outdated and illogical, the main idea is to achieve the concept behind the design and not the just the physical aspect of the design. Hence, it is recommended that the courtyard design be incorporated into the design of new Saudi housing projects, but not necessarily in the pure vernacular sense. This incorporation can be achieved in a more modern and esthetical way that provides privacy for the inhabitants as well as a gathering area that is environmentally comfortable throughout the year.

The fourth and last sustainability challenge is application; several such CSFs in the first Delphi round were discussed. The application of sustainability must be through the approval of Saudi Government bodies such as the MOHPW. What is controversial is that the stakeholders ranked the involvement of the Saudi Government to be low, indicating that the Saudi Government must move vigorously to be involved in the application and development of sustainable housing projects in the country. Since Saudi Arabia is still under constant development, as discussed in the literature review, the successful development of sustainable housing projects that are also affordable is still feasible. One of the CSFs discussed in the first Delphi round is that the Saudi Government must lead by example, which can be achieved through incorporating or applying sustainability to the buildings of the Saudi

Government. Some current projects have adopted the concept of sustainability and have utilised the LEED sustainability rating system, as discussed in the literature review. This act of application of sustainable construction methods to government buildings will help hasten the application of sustainability to future housing projects, but it needs to be applied and incorporated in the SBC and mandated to be applied at least to a minimum level.

The results from the second Delphi round indicated that the following CSFs have reached consensus. These are categorised according to the corresponding four sustainability factors discussed in this thesis:

Economic CSFs

- financial incentives (subsidies)
- energy efficiency
- affordable to the resident
- low-maintenance cost
- use of green energy
- recycling material (waste)
- provision of affordable sustainable housing units
- the Saudi Government should intervene by reducing land prices
- the Saudi Government should pay the upfront payment of sustainable housing projects
- increase amount of public loans provided by the Saudi Government
- offer more vacant lands for residential purposes
- the Saudi Government should plan for smaller land sizes.

Socio-cultural CSFs

- suitable for the local environment and culture
- the traditional courtyard has social impact
- incorporate the Mashrabiyas in an efficient and modern way
- passive cooling can be achieved utilising the techniques behind vernacular elements, such as wind towers
- Saudi Arabia's unique Islamic culture must be reflected in modern designs of houses.

Environmental CSFs

- applying sustainable construction methods that meet the environmental comfort needs of residents
- employing (absorbing) the local weather
- building from local materials
- thermal insulation
- indoor air quality
- passive cooling
- physical health (wellbeing)
- accessibility (near all amenities)
- mental health
- grey/rain water treatment
- landscape design
- water insulation (interior insulation).

Application CSFs

- educating the public on the advantages of sustainable housing
- educating firms on how to design sustainable housing
- implementing new laws that enforce sustainable methods
- all designing firms should have a good understanding of the SBC
- new housing projects must use the SBC
- existing houses need to be renovated to reach the minimum level required by the SBC.

The above-mentioned CSFs are critical to the development and application of sustainability to housing in Saudi Arabia. They must be included in future amendments of the SBC that would allow them to be mandatory for future housing construction developments. These CSFs helped formulate the model that is the main outcome of this thesis: the successful application and incorporation of all the CSFs will help Saudi developers to build sustainable housing projects that are suitable for the local Saudi culture and environment as well as being economically feasible for low- and middle-income families. The CSFs can also help in the development of a unique Saudi sustainability rating system that deals with the local unique conservative Islamic culture and harsh arid climatic conditions.

The case studies have proven that several enablers, if applied, can make a huge difference in achieving sustainability. The third case study, for example, applied only minor sustainability measures by installing thermal insulation and water control fixtures in kitchens and toilets, and yet the amount of energy and water reduction was highly noticeable, reaching 32.4 per cent in energy reduction and a potential

55.4 per cent in water reduction. Additionally, the importance of public awareness and design firm awareness is one of the main outcomes from the case studies. This is due to the applicability of sustainability measures when the occupants knew of the potential benefits of applying sustainability measures to the design (in the first two case studies) and to the existing building (in the third case study).

To conclude the discussion on CSFs, the key Saudi stakeholders agreed that educating the public as well as design firms is a high priority and that the Saudi Government is responsible for carrying out these tasks to insure that the development of sustainable housing in the country will be accepted by the public if they have knowledge on the benefits of this type of construction. The second high priority factor is concerned with the Saudi Government and its role in implementing new laws that mandate the use of sustainable construction methods on housing in the country and should also provide incentives for dwellers who apply this type of construction method. Finally, the Saudi culture and environment is unique, and the stakeholders agreed that it is of high priority to consider these unique aspects in any housing design or construction in the future.

8.4 INFLUENCE OF SAUDI CULTURAL AND ENVIRONMENTAL FACTORS ON THE DEVELOPMENT OF SUSTAINABLE HOUSING

The response to this research question is categorised into two sections—cultural factors and environmental factors. The two sections are discussed based on the outcomes from the various data collection methods.

8.4.1 Cultural Factors Discussion

The extensive literature review was examined in relation to the unique Saudi culture. Discussion in the literature revealed the importance of incorporating the unique Islamic culture of Saudi Arabia into the design of a house (Abu-Ghazzeh, 1996; Al Mubarkpuri, 2003; Burkhart & Goodman, 1998; Champan et al., 2000; Daneshpour, 2011; Gamboa, 2008; Mahmud, 2009; North & Tripp, 2009; Sidawi, 2008). It was argued that the conservative Islamic culture of Saudi Arabia needs certain design aspects to be available for the inhabitants to feel comfortable. These design aspects include achieving privacy, segregation between male and female parts of the house, segregating between what is private and what is public, and finally, proximity to a Masjid. These vital cultural aspects were treated as a framework for the development of the interview question and the two Delphi rounds, in addition to the selection of case studies.

In the semi-structured interviews, the participants were asked to evaluate their knowledge of the SBC and its relation to the unique Saudi culture. Four of the nine participants knew the SBC but the majority of them did not agree that the SBC addresses the unique Saudi culture. Some of the participants even suggested that the SBC is the same as the American building codes, with some modification to suit the country but not the culture. Further, one of the participants argued that even when a developer or a designing firm knows the SBC, it is never followed to the letter and some clauses are neglected for one reason or another. Hence, the participants in the interviews recommended that a specific tailored sustainable construction system must be developed to meet the local cultural needs.

Responses from the first Delphi round to the incorporation of the Saudi culture into the design of houses indicated that there is a gap between what the Saudi public has and what they should have in their houses. This is due to applying Westernised villa typology designs in a community that does not need that type of design. One vital design aspect that presents several cultural as well as environmental comforts to residents is the incorporation of courtyards in the design of a Saudi house. This courtyard design serves to achieve cultural aspects, such as privacy, in addition to providing passive cooling and natural lighting during the day, if designed appropriately. The two highest ranked elements in the culture question in the first Delphi round were both related to the courtyard design. Hence, it is highly advisable that the trend of designing Western villas for the Saudi population diminish and the use of courtyard designs in houses increases.

In the second Delphi round, the participants reached consensus on the courtyard design aspect and realised that vernacular architectural elements that served cultural, environmental and economic aspects of sustainability should be incorporated into new housing designs. The participants argued that the current Saudi housing design does not reflect the cultural needs of the Saudi public. This consensus accentuates the need to incorporate the unique conservative Islamic culture into the design of Saudi houses by infusing vernacular architectural elements either in physical or conceptual form. This fusion will ensure that construction reflects the unique culture of the Saudi community in its design and will provide sustainable solutions that fulfil the three pillars of sustainability.

The analysis of the three case studies chosen validate that the incorporation of the unique conservative Islamic culture of Saudi Arabia into designs can be achieved. The Fence house, for example, reflected the Saudi culture and provided the courtyard design. The architect who designed the Fence house also incorporated passive cooling and natural day lighting. The Landform house respected the culture by having a garden in the courtyard with water features that replicated traditional Islamic architecture. Additionally, the Landform house separated the public from the private parts of the house quite distinctively. Such case studies provide evidence that the unique Saudi culture can be incorporated into the design of houses, which can be sustainable at the same time. The third case study lacked the full incorporation of Saudi culture into the design of the building, mainly because the building was already under construction and it was difficult to change or modify the design. However, the developer aimed at providing sustainable insulation that conserved energy and also provided water control fixtures that conserved water. Therefore, it is vital that Saudi cultural requirements be incorporated into the early stages of the design of houses, which will help implement the concept of sustainability within the unique Saudi culture.

8.4.2 Environmental Factors Discussion

Several challenges were discussed in the literature review regarding the environmental factors affecting the design a Saudi house. Because of the harsh arid climatic conditions of the country, it is vital that these environmental factors be considered in the design of a Saudi house. From the literature, the traditional Saudi houses respected the environment and designed the house in a way that can provide an indoor environment that is comfortable for its occupants. However, the literature showed that after the country's 'oil-boom' phase, the design of a Saudi house was sadly and irrationally mimicking Western-housing designs. This shift in design practices not only neglected the cultural needs as discussed earlier, but neglected the environmental needs that resulted in the vast sums of energy consumed to cool the indoor environment.

Several environmental factors were extracted from the literature review. Participants were given the opportunity to express their concerns and affirmed these factors. The participants' concerns include:

- passive cooling
- energy saving
- water insulation (interior insulation)
- water conservation
- thermal insulation
- thermal comfort
- landscape
- site orientation.

The response to the above-mentioned environmental factors from the first and second Delphi rounds indicated that six of the eight environmental factors are considered high value and should be considered and implemented in housing design in Saudi Arabia. The six highly ranked environmental factors are:

- passive cooling
- energy saving
- water conservation
- thermal insulation

- thermal comfort
- site orientation.

Environmental comfort in a Saudi house can be achieved through the use of vernacular concepts. The main aim is to permit the flow of natural air through the interior, which is possible using courtyards, Mashrabiyas and wind towers. Natural lighting, which involves harvesting the sunlight, can also be achieved by designing the windows according to the optimal location in accordance with the orientation of the house. In doing so, it is vital that the placement of windows and doors still aligns with the cultural aspect of privacy.

It is very promising that all of the three case studies selected as sustainable have considered these six environmental factors and have incorporated them into the design. The Landform house, for example, has the four designed roofs covered with PV panels the harvest the sun's energy and powers the house. Additionally, its construction respected the form of the land and was designed around the contours of the land, which resulted in minimal impact on the site's environment. The non-sustainable case study, however, indicated that neglecting the environmental uniqueness of Saudi Arabia resulted in requiring more than 80 per cent of the energy usage just to cool the building's indoor environment. Thus, it is vital that future Saudi housing designs respect the unique harsh climatic conditions of Saudi Arabia and incorporate sustainability measures that will have a positive impact on the environment and save on energy costs as well.

8.5 A MODEL FOR SUCCESSFUL DEVELOPMENT OF SUSTAINABLE HOUSING FOR LOW- AND MIDDLE-INCOME FAMILIES IN SAUDI ARABIA

The main outcome of this thesis is the formation of a model that will help the successful development of sustainable housing in Saudi Arabia and the adaptation of the unique conservative Islamic culture of Saudi Arabia into the design of sustainable housing. This is to be achieved in a way that is economically viable for low- and middle-income families. The model was constructed based on the findings from the primary and secondary data that categorised four challenges facing sustainability in the housing construction industry in Saudi Arabia. The model represents the highest ranked factors where each category has the highest ranking factor first followed by the less ranked factors in an anti-clockwise direction. Successful implementation of this model will support the development of sustainable housing in Saudi Arabia that meets the local unique cultural and environmental requirements. The model can also be utilised to help develop a sustainability rating system that is specifically designed for Saudi Arabia, while referring to global and regional sustainability rating systems.

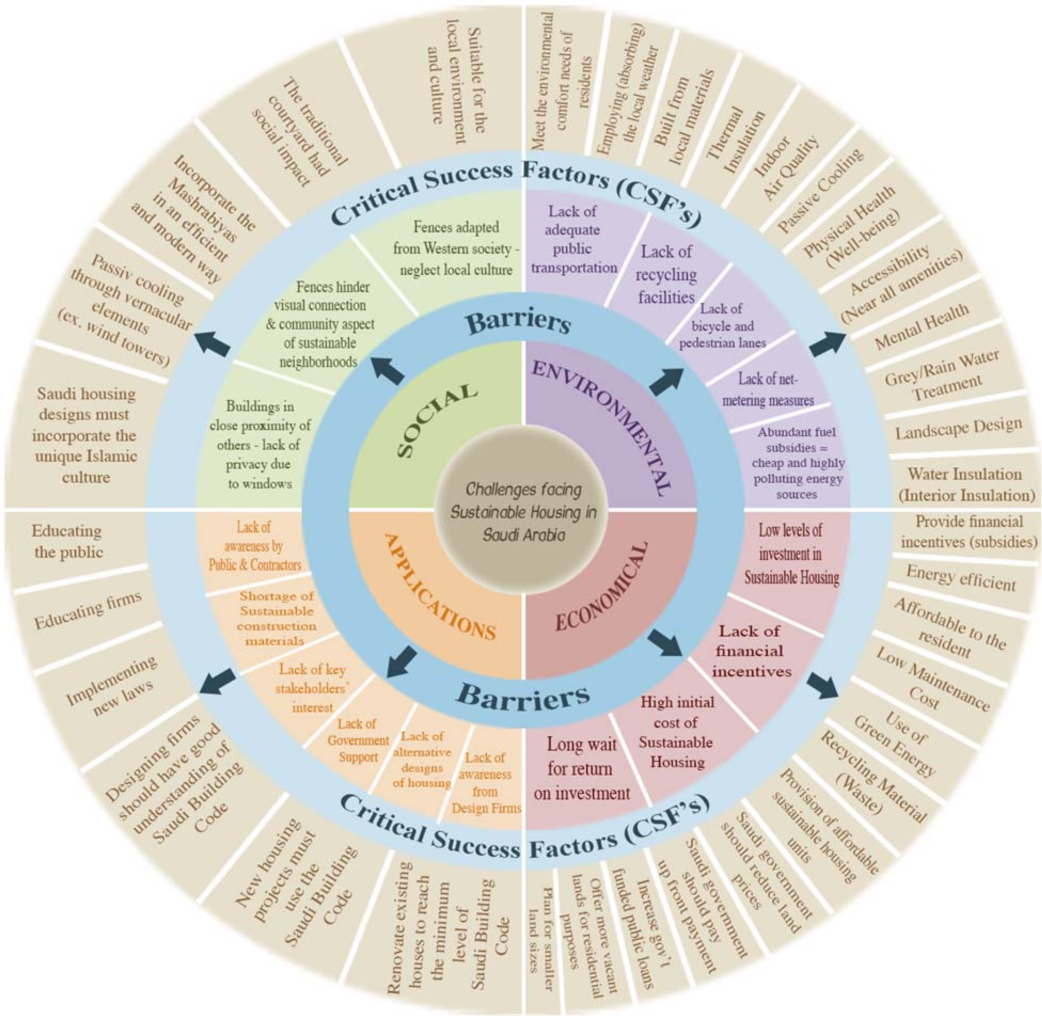

Figure 8.2. Model for successful development of sustainable housing in Saudi Arabia.

Chapter 9: Conclusion

9.1 INTRODUCTION

It is clear that Saudi Arabia is currently facing a crisis in the supply of affordable and sustainable housing, and that trends of human consumption suggest a potential catastrophe when the natural supplies of non-renewable energies and materials expire. These factors, as well as the rate of rapid population growth and increases in urbanisation, which place more strain on an already insufficient infrastructure, compounded by the inability of the masses to afford sufficient housing, make it all the more important that a valid solution is soon presented to Saudi society.

9.2 CONCLUSION OF THE RESEARCH

Not only is Saudi Arabia still in the developmental stage concerning infrastructure for its urban regions, but this is complicated by the rapid growth of urbanisation over a short time span as well as by the severe harsh climate. Compounding this further is the culture of the society, termed the most modestly conservative nation in the world, as seen in the segregation of the sexes not only in the public arena but within the private home. This, combined with the lack of current affordable housing, has proven to be a great barrier for the typical middle-class Saudi when purchasing or building their own homes. All of this indicates the ultimate need to introduce sustainability into the housing sector of Saudi Arabia.

Sustainability has been defined as development that meets the needs of the current generation without compromising the needs of future generations. This development must interconnect three essential factors—environmental, economic and socio-cultural factors—in addition to a fourth factor stipulated in this research, which is the application factor. Failure to meet these four factors leads to disequilibrium in the application of sustainability. Sustainability can be applied to all aspects of life, but this research focused on housing in Saudi Arabia. Applying sustainability to housing development requires the collaboration of all key stakeholders from government, private and academic sectors of the country. This collaboration will eradicate any difficulties of applying sustainability to the housing development in the country, which includes vagueness of the definition of 'sustainability' and lack of public knowledge of the benefits of applying this method of construction. Collaboration will also incentivise the building material industry to produce sustainable building materials that the country desperately needs.

Multiple benefits of applying sustainable construction methods to housing in Saudi Arabia were discussed in the literature review, covering the three pillars of sustainability. These benefits include energy and resource conservation, pollution reduction, waste and environmental degradation, and the implementation of comfortable and healthy living environments. Statistically, sustainable buildings can decrease energy consumption by approximately 30 per cent, water consumption by 30 per cent to 50 per cent and overall costs by 50 per cent to 90 per cent. One staggering statistic is that buildings in Saudi Arabia utilise over 81 per cent of energy for cooling purposes alone. This can be immensely reduced if sustainability measures are practiced, providing multiple benefits, one of which is reduction in energy consumption, while the other is natural resource conservation. Sustainability measures were discussed in detail in the literature review, and include:

- better insulation
- more energy-efficient heating, cooling, ventilation, and refrigeration systems
- efficient fluorescent lighting
- passive heating and lighting to take advantage of sunlight
- the purchase of energy-efficient appliances and electronics.

GCC countries are faced with unique challenges, as discussed in Chapter 2. The dominant challenges are related to energy consumption and depletion of natural resources, caused by rapid population growth and high urbanisation levels. GCC countries have sought to solve part of the natural resource depletion problem, water scarcity, by building desalination plants that produce fresh water for the region. This solution might seem harmless but these desalination plants consume large amounts of energy and are powered by non-renewable sources. Natural water harvesting methods must be mandated in all buildings in the region to reduce the need for desalination plants, or at least increase the number of desalination plants that are powered by renewable energy sources. The literature review showed that in a period of 20 years, GCC countries have rocketed in energy consumption from just over 200,000 GWh in 2000 to reach a forecasted 700,000 GWh in 2020, which is more than a threefold increase. However, it is encouraging to see that GCC countries are taking several sustainability measures to ensure long-term sustainable growth. Such measures include:

- proposing energy efficiency measures and techniques
- capitalising on renewable energy and clean fuel supplies
- increasing water efficiency by using water efficient fixtures
- financing new renewable-energy powered water desalination plants and increasing capacity
- buying or leasing agricultural land abroad.

It is evident that several predicaments are causing the housing industry in Saudi Arabia to fall short in providing adequate sustainable and affordable housing for its residents. Such predicaments include high rate of urbanisation, rapid growth in cities, infrastructure demand not coping with the development, absence of defined boundaries for the city, and lack of laws against those who penetrate the city boundaries. These are not the only difficulties facing the Saudi housing industry—environmental, economic and socio-cultural challenges are also causing complications. Environmental challenges are evident in the harsh arid climatic conditions of the country, which requires large amounts of energy to make the indoor environment of any building comfortable for its inhabitants. This has led the country to require 4.5 hectares of ecological footprints per person, which is roughly twice the world average. Economic challenges are unusual for an oil-rich country but, as in any country, adequate affordable housing seems to be a great challenge for low- and middle-income families. What is more, the ratio of renting as compared to owning property in Saudi Arabia is very high, with about 70 per cent of residents living in rented housing. Saudi property developers are reluctant to even build sustainable and affordable projects because of near-to-non-existent mortgage financing, contributing further to the housing deficit as compared to the needs of the community.

The climatic, economic and cultural conditions of Saudi Arabia are unique, requiring specific study and analysis. Cultural uniqueness is found in the conservative Islamic culture of the population, which requires several design aspects to be respected and implemented. This includes segregation between the male and female sections of the house, privacy both in public and private, and locations relatively close to a Masjid. Vernacular architecture of the country achieved all cultural aspects and provided a healthy environment for its inhabitants in which to live and thrive, but Westernisation spread throughout the country after the 'oil-boom' phase and most of the vernacular design aspects were neglected. A middle-ground can be reached if vernacular architecture methods are infused in modern designs. Addressing the necessary crucial design aspects can provide sustainable houses for the Saudi population that are inspired by the traditions and cultural beliefs of the Saudi community.

The data collected in this research validate the findings from the literature review, in that one of the key barriers in applying sustainability to housing in the country is lack of public awareness of what sustainability means and what its benefits are. The stakeholders involved in the data collection stage of this research had great knowledge of sustainability and its benefits, but they had a lack of interest because of lack of government support and incentives for applying sustainable construction methods. Further, there was lack of regulations being imposed on the type of construction material used in housing units. Even though some global sustainability rating systems, such as LEED, are applied to some buildings in the country, they are unsuitable for Saudi buildings in general and houses in particular because they lack certain necessary Saudi cultural and environmental. This was also validated by the responses of stakeholders, who found the LEED sustainability rating system, for example, did not take into account major Saudi cultural, environmental and economic factors.

This thesis analysed three case studies and showed that sustainability measures such as energy and water conservation methods can be applied in housing units in Saudi Arabia. The case studies also validated that the unique conservative Islamic culture of Saudi Arabia can be incorporated in housing design through constructing a courtyard that achieves privacy and provides natural ventilation for the adjacent rooms. Affordability was also achieved in the third case study by the construction of an apartment as opposed to a house. Sustainability measures were also applied to the apartment building: special thermal insulation was added to the walls and roof, which decreased the overall energy consumption by 32 per cent. Additional measures included the installation of water flow reduction fixtures that reduced the overall consumption of water by more than 55 per cent. The case studies are proof that sustainability measures can be applied to housing units in Saudi Arabia and can provide a comfortable environment for its inhabitants, be affordable for low- and middle-income families and fulfil the required socio-cultural factors such as privacy and segregation.

9.3 ORIGINAL CONTRIBUTION/IMPLICATION

The unique and original findings of this research provide a number of contributions to the body of knowledge and practice, applicable to both industry and academia. The following are considered the major contributions:

- This research has added to the body of knowledge in relation to the challenges facing the application of sustainable construction methods to housing in Saudi Arabia.

- This research identified the gap between academic researchers, who have recognised the unique conservative Islamic culture of Saudi Arabia, and practitioners, who have used and developed sustainable housing construction. This research bridged this gap by elaborating on how to incorporate the unique conservative Islamic culture of Saudi Arabia into sustainable housing construction.

- This research has also bridged the gap between the development of general sustainable housing construction and the development of specific sustainable housing construction projects for Saudi Arabia that incorporate the harsh arid climate conditions of the country and meet unique socio-cultural aspects such as privacy.

- Two major surveys were conducted as part of the data collection phase of this research, which provided valuable information that can be explored in future research related to this field of study.

- This study proposed a model for the successful development and application of sustainability to housing construction in Saudi Arabia. The model consists of four sustainability categories to be followed: environmental, economic, socio-cultural and application factors. The successful fulfilment of all the four factors will aid in the development and application of sustainability to housing construction projects in Saudi Arabia.

- Findings of this study have been disseminated in five international refereed conferences and one refereed journal article in the *Smart and Sustainable Built Environment* journal published by Emerald.

9.3.1 Contributions to and Implications for the Industry

This research has clearly argued that without clear contribution from all stakeholders, the development of sustainable housing in Saudi Arabia will remain purely theoretical. The following points outline the implications of the findings from this research for the Government (public) sector and the private sector.

9.3.1.1 Implications for the Government (Public) Sector

The Government should:

- refuse any housing design permits that are not applying sustainability measures
- develop neighbourhoods that have the entire required infrastructure and have at least 10 services such as schools, fire stations, etc.
- mandate the role of the SGBC to develop the Saudi sustainable rating system
- run awareness campaigns on a regular basis
- provide incentives for developers and individuals who use sustainable construction measures
- reduce the legal processing time for sustainable projects
- renovate all existing government buildings to be sustainable
- provide a database containing energy and water consumption figures free for the public
- put restrictions on new developments if they exceed the boundaries of the city
- introduce new vertical (height) permissions and limit further horizontal expansion of the cities
- introduce new transit systems to encourage use of public transportation
- develop new neighbourhoods that use the concept of the urban village
- provide recycling facilities throughout cities.

9.3.1.2 Implications for the Private Sector

The private sector should:

- design new buildings using sustainable methods and standards
- produce or resource new sustainable building materials
- run workshops, seminars and lectures for employees on the importance of sustainability
- educate clients on the benefits of becoming sustainable
- not design houses that will be built in a neighbourhood with no or limited infrastructure
- learn about and incorporate Saudi culture into the design of houses
- modernise vernacular architecture concepts for new houses
- ask for government land grants in exchange for building governmental sustainable buildings.

9.3.2 Contributions to and Implications for Academic Knowledge

This research was conducted with the knowledge of Saudi participants but was limited due to lack of available information accessible from abroad. Thus, the main contribution of this research to academic knowledge is to create a database that contains resources and information for future research on this and related subjects. In addition, the following implications for the academic sector of the KSA have been discovered. The academic sector should:

- mandate sustainable courses in design-oriented degrees across schools and universities
- run public lectures on the benefits of sustainability
- provide real-life examples of sustainable projects and practices on university campuses so that they can be viewed and studied

- run conferences that address sustainability with local capabilities
- create partnerships with the private sector to design and produce new sustainable building materials from local resources
- collaborate with international universities who are leaders in sustainable housing studies to develop sustainable housing-oriented courses and create exchange programmes.

9.4 RESEARCH LIMITATIONS

No research is free from limitation, and limitations also serve to provide opportunities for future research. One of the limitations that faced the semi-structured interviews was that the interviews were conducted over the internet using Skype, which in some instances was problematic due to technical difficulties. When the connection failed and several attempts to reconnect failed, the interview was then continued by phone, which lacked the face-to-face visual advantage of Skype. The second limitation was that participants were reluctant to participate when first approached because they were not sure what would they gain by contributing and were not sure of what was going to be asked of them. However, after a connection was made with the participants over the phone, the process and content was explained and the interviews were conducted and responses collected successfully.

- The limitations in the collection of responses in the two Delphi rounds were predictable but manageable, and include:
- lack of incentive for the participants to respond to the surveys
- long periods of time to respond to the surveys
- some participants having difficulty reading and understanding the English survey, so an Arabic survey was designed and redistributed, which took time
- dropping number pf participants between the two rounds

- small sample number not representing the total population of Saudi Arabia, so the study must be considered an indicative study of selected experts.

The limitations that faced the case study method were mainly due to lack of sustainable projects that had substantial data able to be used in this thesis. Sustainability is considerably new in Saudi Arabia and the concept was first made public and adopted by the Saudi Government in 2010. There have been few projects since then that could be used as case studies for this thesis. Other limitations, aside from lack of projects, included limited available data on the selected projects, and extensive time required to obtain information from project stakeholders.

9.5 FUTURE RESEARCH DIRECTIONS

Saudi Arabia is fast moving towards implementing sustainable and green construction methods, but more data are needed to convince the public and the Government of the necessity of applying such methods now while the country is still under rapid development. This research discussed the challenges facing the application of sustainability to housing in Saudi Arabia from four perspectives—the environmental, economic, socio-cultural and application challenges. Therefore it is fitting to discuss the future research recommendations based on these four perspectives.

Recommendations based on the economic aspects of sustainability include the following. The Saudi Government should promote the use of sustainable technologies, such as water-saving devices, for example, in faucets, showerheads and kitchen sinks, where consumption reduction can reach up to 49 per cent. Energy saving techniques must be applied in housing in Saudi Arabia, and can result in an overall reduction in energy consumption that can reach more than 50 per cent. Further, low-cost, long-term maintenance measures need to be considered in housing designs in Saudi Arabia for future housing projects.

Environmental recommendations for future research include the following. It is important from the onset of any project to keep in mind the geographical and environmental influences of Saudi Arabia's harsh arid climate. It is also recommended that the incorporation of the concepts behind vernacular architectural elements, such as the Mashrabiya and the courtyard, into new modern Saudi housing designs can provide environmentally sustainable outcomes. This has been discussed in various parts of this thesis and has been validated by the data collected.

Socio-cultural recommendations for future research include the following. It is recommended that future research and analyses are undertaken on constructed residential buildings to evaluate the effectiveness of utilising sustainable methods and to validate the outcomes of this thesis, which have specifically adopted the unique Islamic conservative culture of Saudi Arabia. It is also recommended that stakeholders who are in decision-making positions mandate the incorporation of the unique conservative Islamic Saudi culture into the design of new houses. Designs should reflect on what was achieved in vernacular designs and not mimic Western designs that do not meet the local community's needs.

Application recommendations for future research include the following. Public awareness or rather the lack thereof, is one of the key obstacles in the development of sustainable housing in Saudi Arabia. Therefore, it is recommended that concentrated public awareness campaigns be launched across the country to educate the Saudi public on the benefits and the necessity of applying sustainable construction methods while the country is still under rapid development. It is also recommended that Saudi stakeholders become involved in reducing the restraints of bureaucracy to help hasten the application of sustainability to current and future construction projects. Finally, the Saudi Government need to mandate new laws to reduce the overall consumption of energy and water and to reduce the depletion of natural resources. This can be achieved through the development of a unique sustainability rating system that is designed specifically for Saudi Arabia.

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Appendices

Appendix A: Semi-Structured Interview Invitation to Participate & Questions

Queensland University of Technology Brisbane Australia	**PARTICIPATE IN RESEARCH** **Information for Prospective Participants**

The following research activity has been reviewed via QUT arrangements for the conduct of research involving human participation.

If you choose to participate, you will be provided with more detailed participant information, including who you can contact if you have any concerns.

Challenges Facing Sustainable Housing In Saudi Arabia

Interview Questions

1. Please state your work experience and relativity to the construction industry. Including any sustainable projects (if any).
2. What is your interpretation of Sustainable Development, specifically in the housing industry (sustainability definition)?
3. What parameters/factors of sustainability do you account for when dealing with a housing project (the triple bottom line of sustainability)?
4. What are the critical success factors and/or barriers for applying sustainability to housing in Saudi Arabia and how can barriers be managed?
5. In your opinion, does the Saudi Building code discuss or relate to the cultural needs of the Saudi population and their unique cultural characteristics?
6. In your opinion, what environmental factors must be addressed in design of a Saudi house to make it sustainable?
7. What features of the vernacular architecture of Saudi Arabia would you like to see back in today's Saudi houses, or do you even agree that they should be incorporated into the design of a house, for example the wind towers, the Mashrabiya, the inner courtyards, etc.? Please see Figures 1,2, 3 and 4 for illustrative purposes.
8. One of the crucial elements in the design of a Saudi house is it must provide a well private and out of the sight range of passing pedestrians. In your opinion how can privacy be achieved in a sustainable way in a Saudi house?
9. How do Low and Middle-Income families afford houses in the current Saudi real-estate market, and how differently would you like it to be (if any)?
10. It is well known that the initial payment for a sustainable house is higher than a normal house. How can Low and Middle-Income families afford to pay for sustainable houses, and can the government intervene in making it more affordable (i.e. Incentives, Grants)?

Appendix B: Semi-Structured Interview Invitation to Participate and Ethical Clearance Form

PARTICIPANT INFORMATION FOR QUT RESEARCH PROJECT

– Interview/ Case Study –

CHALLENGES FACING SUSTAINABLE HOUSING IN SAUDI ARABIA

QUT Ethics Approval Number 1200000368

RESEARCH TEAM

Principal Researcher:	Mohammed Al Surf – PhD Student – Science and Engineering Faculty – QUT
Associate Researchers:	Dr Connie Susilawati and Dr Bambang Trigunarsyah, QUT

DESCRIPTION

This project is being undertaken as part of a PhD research for Mohammed Al Surf.

The purpose of this project is to gather information regarding the challenges facing the application of sustainability on housing in Saudi Arabia. The aim of this project is to develop a framework that can be used by the government for applying sustainability on housing projects for low and middle – income families in Saudi Arabia.

A qualitative approach using Delphi method in data collection process is used to develop this framework. Delphi method is conducted in order to find conformity and consensus amongst panel members for the proposed framework. In this research, there will be three rounds in the Delphi process in addition to a case study analysis. The first round is to develop the model, the second round is to evaluate the model, and the final round is to finalize the model. In Delphi round one, in-depth interview will be conducted in order to gather and explore the complexity of information to develop the proposed framework and to sharpen and detail questionnaires for Delphi round two. The interview process will be recorded therefore it can be transcribed and analyzed. In Delphi round two and round three, the panel members are asked to rate their answers on a Likert-type scale, a scale to specify level of agreement or disagreement for a statement, and provide their rationale when there are minority different responses. The final comments will be requested for finalizing the framework. The case study analysis will be carried out on a sustainable construction project in Saudi Arabia where a number of stakeholders will be interviewed regarding the application of sustainability on the project and what were the barriers and enablers to that project.

The research team requests your assistance in the first round of the data collection because your expertise and input will be vital to the outcomes of the research

PARTICIPATION

Your participation in this project is entirely voluntary. If you do agree to participate, you can withdraw from the project without comment or penalty. If you withdraw, on request any identifiable information already obtained from you will be destroyed. Your decision to participate, or not participate, will in no way impact upon your current or future relationship with QUT or with any other parties.

Your participation will take approximately 1.5 hours of your time. The questions will cover:

- How would you rate your knowledge on the concept of sustainability and its application to the housing industry?

- What is your involvement in the application of sustainable methods to the construction of Saudi houses (if any)?

- In order to enhance livability, a Saudi resident must have all his/her needs within walking distance. Do you consent to this concept and how effective is its applicability in the Saudi housing industry?

- Do you agree that applying sustainable solutions would minimize the daily living costs in a Saudi house? Please discuss

- Can passive solar design be applied in Saudi houses and can Low and Middle income families afford it?

EXPECTED BENEFITS

It is expected that this research might not directly benefit you but it might have the benefit of you in seeing other panel members' opinions on the questions and it will enhance your understanding of what other professionals think and what is their understanding of the topic. This research also provides useful input for housing construction project stakeholders.

To recognize your contribution should you choose to participate, the research team is offering participants the chance to view the outcomes of the questionnaires and a brief summary of the results as well.

RISKS

There are no risks beyond normal day-to-day living associated with your participation in this project.

PRIVACY AND CONFIDENTIALITY

All comments and responses will be treated confidentially and will be made anonymous when transcribed. The names of individual persons are not required in any of the responses. No one other that the research team listed above will have access to the online questionnaire data.

Any data collected as part of this project will be stored securely as per QUT's Management of research data policy.

CONSENT TO PARTICIPATE

We would like to ask you to sign a written consent form (enclosed) to confirm your agreement to participate.

QUESTIONS / FURTHER INFORMATION ABOUT THE PROJECT

If have any questions or require any further information please contact one of the research team members below.

Mohammed S. Al Surf	Dr Connie Susilawati	Associate Prof Bambang Trigunarsyah
+61 413 447 401	+61 7 3138 1853	+61 7 3138 8303
mohammed.alsurf@student.qut.edu.au	c.susilawati@qut.edu.au	bambang.trigunarsyah@qut.edu.au

CONCERNS / COMPLAINTS REGARDING THE CONDUCT OF THE PROJECT

QUT is committed to research integrity and the ethical conduct of research projects. However, if you do have any concerns or complaints about the ethical conduct of the project you may contact the QUT Research Ethics Unit on +61 7 3138 5123 or email ethicscontact@qut.edu.au. The QUT Research Ethics Unit is not connected with the research project and can facilitate a resolution to your concern in an impartial manner.

Thank you for helping with this research project. Please keep this sheet for your information.

QUT Queensland University of Technology Brisbane Australia	**CONSENT FORM FOR QUT RESEARCH PROJECT** **– Interview/ Case Study –**

CHALLENGES FACING SUSTAINABLE HOUSING IN SAUDI ARABIA

QUT Ethics Approval Number 1200000368

RESEARCH TEAM CONTACTS

Mohammed S. Al Surf	Dr Connie Susilawati	Associate Prof Bambang Trigunarsyah
+61 413 447 401	+61 7 3138 1853	+61 7 3138 8303
mohammed.alsurf@student.qut.edu.au	c.susilawati@qut.edu.au	bambang.trigunarsyah@qut.edu.au

STATEMENT OF CONSENT

By signing below, you are indicating that you:

- Have read and understood the information document regarding this project.
- Have had any questions answered to your satisfaction.
- Understand that if you have any additional questions you can contact the research team.
- Understand that you are free to withdraw at any time, without comment or penalty.
- Understand that you can contact the Research Ethics Unit on+61 7 3138 5123 or email ethicscontact@qut.edu.au if you have concerns about the ethical conduct of the project.
- Understand that non-identifiable data collected in this project may be used as comparative data in future projects.
- Agree to participate in the project.

Please indicate:

☐ I agree for the interview to be audio recorded.

☐ I do not agree for the interview to be audio recorded.

Name ______________________________

Signature ______________________________

Date ______________________________

Please return this sheet to the investigator.

Appendix C: First Delphi Round Survey

Dear Sir/Madam
Greetings

I'm Mohammed Al Surf and I'm a PhD student studying in the Faculty of Science and Engineering at the Queensland University of Technology. My research for my PhD is about the Challenges Facing the Application of Sustainability on Housing in the Kingdom of Saudi Arabia. As a PhD student, I'm requested to investigate the research questions through the selection of panel members to be part of my research.

The purpose of this project is to gather information regarding the challenges facing the application of sustainability on housing in Saudi Arabia. The aim of this project is to develop a framework that can be used by the government and all construction stakeholders for applying sustainability on housing projects for low and middle–income families in Saudi Arabia.

A qualitative approach using Delphi method in data collection process is used to develop this framework. Delphi method is conducted in order to find conformity and consensus amongst panel members for the proposed framework. In this research, there will be three rounds in the Delphi process. This second round is a result of the first Delphi round which was an interview. In Delphi round two and round three, the panel members are asked to rate their answers on a Likert-type scale, a scale to specify level of agreement or disagreement for a statement, and provide their rationale when there are minority different responses. The final comments will be requested for finalizing the framework.

The research team requests your assistance in the questionnaire phase of the data collection because your expertise and input will be vital to the outcome of the research The normal time it will take to complete the questionnaire will range from 20 to 30 minutes. Your answers will be dealt with in discrete manner and general results from your answers will be included in the final research document. Please feel free to contact me with any questions you may have regarding this issue.

With Best Regards

Mohammed S. Al Surf
PhD Candidate
School of Civil Engineering and Built Environment
Science and Engineering Faculty
Queensland University of Technology
Brisbane, Australia
Mohammed.alsurf@student.qut.edu.au

Section 1: Definition

It's well known that the main factor behind the development of sustainability is to make sure that natural resources are not jeopardized for future generations. Several factors go into the definition of sustainability, which includes environmental factors, economical factors as well as social factors; the three factors formulate the sustainability triangle. Please select the appropriate level of agreement to the following elements

	Sustainable housing is any housing, which proves to be	**Strongly Disagree**	**Disagree**	**Slightly Disagree**	**Slightly Agree**	**Agree**	**Strongly Agree**
1	Environmentally friendly						
2	Has low-cost long-term maintenance						
3	Affordable to the consumer						
4	Built from local materials						
5	Suitable for the local environment and cultures						
6	Employing (absorbing) the local weather						
7	Energy efficient						

Please Comment on any of the above elements

Section 2: Sustainability Factors

The importance of sustainability is that it should be implemented in the early stages of the project starting from the feasibility stage and should implement several factors. Please select the appropriate level of agreement to the following elements

	Sustainability Factors	Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
1	Optimum use of Local material						
2	Use of Green Energy						
3	High Initial Cost						
4	Low Initial Cost						
5	High Maintenance Cost						
6	Low Maintenance Cost						
7	Physical Health (Wellbeing)						
8	Mental Health						
9	Indoor Air Quality						
10	Structural Quality						
11	Thermal Comfort						
12	Passive Cooling (Less use of mechanical cooling)						
13	Natural Lighting						
14	Natural Ventilation						
15	Recycling Material (Waste)						
16	Water Conservation						
17	Grey/Rain Water Treatment						
18	Thermal Insulation						
19	Accessibility (Near all amenities)						
20	Site Orientation						

What materials can be used that are sustainable in the Saudi construction market? (Please Discuss)

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Section 3: Barriers

The following statements are considered barriers to applying sustainability to housing in Saudi Arabia according to the literature. Please select the appropriate level of agreement to the following elements

	Sustainability Barriers	Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
1	Lack of public awareness on the benefits of sustainable housing						
2	Lack of key stakeholders' interest in applying sustainable housing						
3	Shortage in sustainable construction material						
4	High initial cost of sustainable housing						
5	Long period of return of investment (Payback period)						
6	Low levels of investment in sustainable housing						
7	Lack of alternative designs of housing						
8	Lack of awareness from designing firms of how to design sustainable housing						
9	Lack of Government Support (Guidelines, Building Codes)						
10	Lack of Financial incentives (Subsidies)						

Please Comment on any of the above elements

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Section 4: Enablers

The following statements are considered enablers to applying sustainability to housing in Saudi Arabia according to the literature if the Saudi government establishes a minimal sustainable housing standard to be applied to housing projects. Please select the appropriate level of agreement to the following elements.

	Sustainability Enablers	Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
1	Educating firms on how to design sustainable housing						
2	Educating the public on the advantages of sustainable housing						
3	Implementing new laws that enforce the utilization of sustainable methods to housing construction						
4	Applying sustainable construction methods that meet the environmental comfort needs of residents						
5	The Saudi government provision of affordable sustainable housing units for Low-income families						
6	Green energy should be the main energy source of sustainable housing in Saudi Arabia such as solar energy						
7	Enforce Rainwater collection and Grey water treatment systems on every housing project, new or old.						
8	A resident in a Saudi neighborhood should have all his/her basic needs						

	within walking distance such as a mosque, a shopping center, and all government offices.						
9	The Saudi government should provide financial incentives (subsidies) to whoever applies sustainable construction methods to their house						

Please Comment on any of the above elements

Section 5: The Saudi Building Code

The Saudi Building Code is a set of rules and regulations that designers, contractors and all construction stakeholders should/must refer to and it was approved and published in 2007.

Please select the appropriate level of agreement to the following elements.

	The Saudi Building Code	Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
1	I have heard of the Saudi Building Code						
2	This is the first time I hear of the Saudi Building Code						
3	The Saudi Building Code is new to me and I have not used it or had any experience with it						
4	I have extensive knowledge of the Saudi Building Code						
5	I use the Saudi Building Code constantly						
6	Saudi Architectural designing firms don't use the Saudi Building Code						
7	The Saudi Public has knowledge about the Saudi Building Code						
8	All designing firms should have a good understanding of the Saudi building code						
9	Increase public awareness of the Saudi building code, e.g. through local media.						
10	New housing projects must use the Saudi building code at least to the minimum standards						
11	Existing houses						

	need to be renovated to reach the minimum level required by the Saudi building code						

Please Comment on any of the above elements

Section 6: The Saudi government

The Saudi government through several ministries and local municipalities has great influence on the housing construction in Saudi Arabia. This section will get the panel's perception on the role of the Saudi government in the housing construction industry in Saudi Arabia.

Please select the appropriate level of agreement to the following elements.

	The Saudi Government	Never	Very Low	Low	High	Very High	Extremely High
1	How extensive does the Saudi government intervenes in the design and construction of houses in Saudi Arabia?						
2	How would "change" in the ideas of the Saudi population regarding the application of sustainable methods on housing, be acknowledged by the Saudi government and other official bodies in Saudi?						
3	Design firms stick to and follow the Saudi Building code						
4	The Saudi Building code discuss or relate to the cultural needs of the Saudi population and their unique cultural characteristics						

Please Comment on any of the above elements

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Section 7: Environmental Factors

Several environmental factors must be addressed in the design of a Saudi house to make it sustainable.

Please select the appropriate level of agreement to the following elements.

	Environmental Factors	Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
1	Passive Cooling						
2	Privacy						
3	Energy Saving						
4	Affordability						
5	Water insulation (Interior insulation)						
6	Water Conservation						
7	Thermal Insulation						
8	Thermal comfort						
9	Landscape						
10	Site orientation						

Please Comment on any of the above elements

Section 8: The Saudi culture

Many architectural features and elements have defined the Saudi culture and have proved to serve the unique conservative Islamic culture of the country. Please select the appropriate level of agreement to the following elements.

	The Saudi culture	Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
1	Vernacular architectural elements should be incorporated in today's housing design						
2	Mashrabiyas can be designed in an efficient and modern way and can be incorporated into the design of a Saudi house.						
3	Passive cooling can be achieved utilizing the techniques behind vernacular elements such as the wind towers.						
4	Courtyards can be used to ventilate the house as well as provide natural lighting to adjacent rooms						
5	The traditional courtyard was not just an architectural element. It had social impacts as well. For example a gathering place for the whole family						
6	Saudi Arabia's unique Islamic culture is not reflected in many designs of modern houses.						

Please Comment on any of the above elements

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Section 9: Privacy in the Saudi culture

One of the crucial design features to incorporate into the design of a Saudi house is privacy. Privacy can be achieved by the following:

	Privacy in the Saudi culture	Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
1	Adopting the concept of the courtyard and applying it to the design						
2	Utilizing the Mashrabiyas and covering exterior windows with them						
3	Each block of a Saudi neighborhood should have a common area to use for gathering and parties, and leave the house for personal and family use.						
4	Enforcing the use of landscaping on the exterior parameters of the house and it must be at a certain height that gives privacy to the inhabitants from the eyes of outsiders.						
5	Provision of clearstory fenestration along the room walls instead of typical windows						
6	Designing the house entrance with an L shaped entrance corridor						

Please Comment on any of the above elements

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Section 10: Affordability

Sustainable houses according to the literature should be affordable to all levels of residents.

Please select the appropriate level of agreement to the following elements.

	Affordability	Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
1	Public loans provided by the Saudi government are not enough to buy a piece of land nor a completed/finished house						
2	Promotions for a sustainable lifestyle and advertising via environmental agencies can promote and sponsor portions of the real estate						
3	Offering more vacant lands for residential purposes will help decrease the price range and change the density ratio						
4	No middle and low-income family can afford to buy a house in today's market. They all are borrowing money from somewhere to buy houses						
5	Saudi residents who can't afford to build or buy a house straight off the market, should build their house gradually room by room						
6	The Saudi government should intervene by reducing land prices						
7	The Saudi government should present affordable housing projects						
8	The Saudi government should						

	Affordability	Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
	plan for smaller land sizes so that residents can afford them						
9	The Saudi government should pay the upfront payment of sustainable housing projects to promote the use of sustainable housing						
10	Materials that will be used in sustainable houses need to be sustainable from the fabrication to demolition						
11	Renting a sustainable house can be affordable to Low and Mid-Income families						
12	Closeness and availability of public transport can have a great impact on the sustainability of a house						

Please Comment on any of the above elements

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Section 11: Participant General Information

1. Name:

2. Institution:

3. Position:

4. Type of organization in which you are working:
    a. Government officer
    b. Engineering consultant
    c. Contractor
    d. University

e. Others; please specify

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5. Years of Experience:

Appendix D: Second Delphi Round Survey

Challenges Facing the Application of Sustainability on Housing in the Kingdom of Saudi Arabia

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Dear Sir/ Madam

Thank you very much for responding to the Delphi Questionnaire (Round 1), which has been now analysed. Your feedback was very useful and you responses to the questions have enabled me to move to the next round of the study.

This is the second round questionnaire of the Delphi study on identifying stakeholder agreement on issues regarding sustainable housing construction in Saudi Arabia. This survey has been divided into two sections. Section 1 is for elements that need re-ranking to reach maximum consensus from all participants. Whereas section 2 lists all the elements that have reached consensus and do not need to be re-ranked and they are only displayed here for your reference. It is estimated that this questionnaire will take approximately 8 to 15 minutes to complete.

The current understanding and the factors have been analysed and rated based on the results from all first round questionnaire respondents. Your opinion is required to evaluate the agreement on issues regarding sustainable housing construction in Saudi Arabia and the factors for implementing sustainable housing construction in Saudi Arabia.

I wish to assure you again that all information provided through this survey would be handled with strict confidentiality and reported in a way so as to preserve the anonymity of the respondents. This study adheres to the ethical procedures and requirements of Queensland University of Technology (QUT). QUT is committed to researcher integrity and the ethical conduct of research projects.

If you have any further questions concerning this survey please do not hesitate to contact the researcher, Mohammed Saied Al Surf at +61413447401 or via email mohammed.alsurf@student.qut.edu.au.

Kindly, return your questionnaire by email at your earliest convenience. Your response will be analysed and synthesised in the coming weeks and you will be contacted for the outcome of the two Delphi rounds.

Once again thank you for your co-operation and support of this study.

The following Tables have been ranked in accordance with the analysis of the first round questionnaire responses. The ranking is arranged based on the mean of the analysis result. Based on your expertise, experience and knowledge, please indicate your agreement or otherwise you can reconsider and revise the ranking by giving the new ranking

Name: ______________________________________

Section 1

In this section of the survey, the following Tables are for you to re-rank them in order to reach maximum consensus. Please agree or revise your rating for items in the Tables below.

Definition of Sustainability

Based on result of Delphi round 1, please consider your rating by providing the agreement on the degree of the agreement below.

High : Agreement of respondents with mean ≥5

Medium : Agreement of respondents with mean ≥4 and <5

Low : Agreement of respondents with mean <4

If you are revising your rating, then please revise it to High, Medium or Low.

Rating of Agreement Result from Round 1	Definition of Sustainability	Agreement		If No Revise the Rating		
		Yes	No	H	M	L
High	Energy efficient	☐	☐	☐	☐	☐

Rating of Agreement Result from Round 1	Definition of Sustainability	Agreement		If No Revise the Rating		
		Yes	No	H	M	L
	Employing (absorbing) the local weather	☐	☐	☐	☐	☐
Medium	Suitable for the local environment and cultures	☐	☐	☐	☐	☐
	Built from local materials	☐	☐	☐	☐	☐
	Affordable to the consumer	☐	☐	☐	☐	☐

<u>Sustainability Factors</u>

Rating of Agreement Result from Round 1	Sustainability Factors	Agreement		If No Revise the Rating		
		Yes	No	H	M	L
High	Thermal Insulation	☐	☐	☐	☐	☐
	Indoor Air Quality	☐	☐	☐	☐	☐
	Passive Cooling (Less use of mechanical cooling)	☐	☐	☐	☐	☐
	Structural Quality	☐	☐	☐	☐	☐
Medium	Use of Green Energy	☐	☐	☐	☐	☐

Rating of Agreement Result from Round 1	Sustainability Factors	Agreement		If No Revise the Rating		
		Yes	No	H	M	L
	Recycling Material (Waste)	☐	☐	☐	☐	☐
	Accessibility (Near all amenities)	☐	☐	☐	☐	☐
	Grey/Rain Water Treatment	☐	☐	☐	☐	☐
	Physical Health (Well-being)	☐	☐	☐	☐	☐
	Low Maintenance Cost	☐	☐	☐	☐	☐
	Mental Health	☐	☐	☐	☐	☐
Low	Low Initial Cost	☐	☐	☐	☐	☐
	High Maintenance Cost	☐	☐	☐	☐	☐
	High Initial Cost	☐	☐	☐	☐	☐

Barriers

Rating of Agreement Result from Round 1	Barriers	Agreement		If No Revise the Rating		
		Yes	No	H	M	L
High	Lack of public awareness on the benefits of	☐	☐	☐	☐	☐

Rating of Agreement Result from Round 1	Barriers	Agreement		If No Revise the Rating		
		Yes	No	H	M	L
	sustainable housing					
Medium	Low levels of investment in sustainable housing	☐	☐	☐	☐	☐
	Lack of Financial incentives (Subsidies)	☐	☐	☐	☐	☐
	Lack of awareness from designing firms of how to design sustainable housing	☐	☐	☐	☐	☐
	Lack of Government Support (Guidelines, Building Codes)	☐	☐	☐	☐	☐
	High initial cost of sustainable housing	☐	☐	☐	☐	☐
	Lack of alternative designs of housing	☐	☐	☐	☐	☐
Low	Shortage in sustainable construction material	☐	☐	☐	☐	☐
	Long period of return of investment (Payback period)	☐	☐	☐	☐	☐

<u>Enablers</u>

Rating of Agreement Result from Round 1	Enablers	Agreement		If No Revise the Rating		
		Yes	No	H	M	L

Rating of Agreement Result from Round 1	Enablers	Agreement		If No Revise the Rating		
		Yes	No	H	M	L
High	The Saudi government should provide financial incentives (subsidies) to whoever applies sustainable construction methods to their house	☐	☐	☐	☐	☐
	Implementing new laws that enforce the utilization of sustainable methods to housing construction	☐	☐	☐	☐	☐
Medium	The Saudi government provision of affordable sustainable housing units for Low-income families	☐	☐	☐	☐	☐
	Green energy should be the main energy source of sustainable housing in Saudi Arabia such as solar energy	☐	☐	☐	☐	☐
	Enforce Rainwater collection and Grey water treatment systems on every housing project, new or old.	☐	☐	☐	☐	☐
	A resident in a Saudi neighbourhood should have all his/her basic needs within walking distance such as a mosque, a shopping centre, and all government offices.	☐	☐	☐	☐	☐

<u>The Saudi Building Code</u>

Rating of Agreement Result from	The Saudi Building Code	Agreement	If No Revise the Rating

Round 1		Yes	No	H	M	L
High	New housing projects must use the Saudi building code at least to the minimum standards	☐	☐	☐	☐	☐
Medium	I have heard of the Saudi Building Code	☐	☐	☐	☐	☐
	Increase public awareness of the Saudi building code, e.g. through local media.	☐	☐	☐	☐	☐
	Existing houses need to be renovated to reach the minimum level required by the Saudi building code	☐	☐	☐	☐	☐
Low	Saudi Architectural designing firms don't use the Saudi Building Code	☐	☐	☐	☐	☐
	I have extensive knowledge of the Saudi Building Code	☐	☐	☐	☐	☐
	I use the Saudi Building Code constantly	☐	☐	☐	☐	☐
	The Saudi Public has knowledge about the Saudi Building Code	☐	☐	☐	☐	☐
	The Saudi Building Code is new to me and I have not used it or had any experience with it	☐	☐	☐	☐	☐
	This is the first time I hear of the Saudi Building Code	☐	☐	☐	☐	☐

The Saudi Government

All the elements of the Saudi Government section were all rated Low; so no re-ranking is needed for this section.

Environmental Factors

Rating of Agreement Result from Round 1	Environmental Factors	Agreement		If No Revise the Rating		
		Yes	No	H	M	L
Medium	Landscape	☐	☐	☐	☐	☐
	Privacy	☐	☐	☐	☐	☐
	Water insulation (Interior insulation)	☐	☐	☐	☐	☐

<u>The Saudi Culture</u>

Rating of Agreement Result from Round 1	The Saudi Culture	Agreement		If No Revise the Rating		
		Yes	No	H	M	L
Medium	Saudi Arabia's unique Islamic culture is not reflected in many designs of modern houses.	☐	☐	☐	☐	☐
	Vernacular architectural elements should be incorporated in today's housing design	☐	☐	☐	☐	☐

<u>Privacy in the Saudi Culture</u>

All the elements of Privacy in the Saudi Culture section were rated Medium, so no re-ranking is needed for this section.

Affordability

Rating of Agreement Result from Round 1	Affordability	Agreement		If No Revise the Rating		
		Yes	No	H	M	L
High	The Saudi government should intervene by reducing land prices	☐	☐	☐	☐	☐
	No middle and low-income family can afford to buy a house in today’s market. They all are borrowing money from somewhere to buy houses	☐	☐	☐	☐	☐
Medium	The Saudi government should pay the upfront payment of sustainable housing projects to promote the use of sustainable housing	☐	☐	☐	☐	☐
	Public loans provided by the Saudi government are not enough to buy a piece of land nor a completed/finished house	☐	☐	☐	☐	☐
	Offering more vacant lands for residential purposes will help decrease the price range and change the density ratio	☐	☐	☐	☐	☐
	Promotions for a sustainable lifestyle and advertising via environmental agencies can promote and sponsor portions of the real estate	☐	☐	☐	☐	☐
	The Saudi government should plan for smaller land sizes so that residents can afford them	☐	☐	☐	☐	☐
Low	Saudi residents who can't afford to build or buy a house straight off the market, should build their house gradually room by room	☐	☐	☐	☐	☐

Section 2

In this section the following Tables are not for revising your rating because the statements have been agreed upon and were ranked as one rank, High or Medium, which means that these sections have reached consensus.

For clarification purposes, the method that was used to analyse the data to determine which statement was ranked as high, medium or low was utilising the standard deviation (SD) calculation method. The standard deviation is the most common measure of variability, measuring the spread of the data set and the relationship of the mean to the rest of the data. If the data points are close to the mean, indicating that the responses are fairly uniform, then the standard deviation will be small. Conversely, if many data points are far from the mean, indicating that there is a wide variance in the responses, then the standard deviation will be large. If all the data values are equal, then the standard deviation will be zero. (Investopedia, 2013). The closer the SD value is to 1 the closer the spread of responses. But if the SD value is greater than 1, then the response values spread widely and get farther from the mean. This is called a normal distribution which represents a normal bell curve. “The Normal Distribution is perfectly symmetric about its mean μ and its spread is determined by its standard deviation σ.” (Terry College of Business, 2010).

Definition of Sustainability

Rating of Agreement Result from Round 1	Definition of Sustainability
High	Environmentally friendly
	Has low-cost long-term maintenance

Sustainability Factors

Rating of Agreement Result from Round 1	Sustainability Factors
High	Natural Lighting
	Water Conservation
	Natural Ventilation
	Thermal Comfort
	Site Orientation
	Optimum use of Local material

<u>Barriers</u>

Rating of Agreement Result from Round 1	Barriers
Medium	Lack of key stakeholders' interest in applying sustainable housing

<u>Enablers</u>

Rating of Agreement Result from Round 1	Enablers
High	Educating the public on the advantages of sustainable housing
	Applying sustainable construction methods that meet the

Rating of Agreement Result from Round 1	Enablers
	environmental comfort needs of residents
	Educating firms on how to design sustainable housing

The Saudi Building Code

Rating of Agreement Result from Round 1	The Saudi Building Code
High	All designing firms should have a good understanding of the Saudi building code

The Saudi Government

Rating of Agreement Result from Round 1	The Saudi Government
Low	How extensive does the Saudi government intervene in the design and construction of houses in Saudi Arabia?
	How would “change” in the ideas of the Saudi population regarding the application of sustainable methods on housing, be acknowledged by the Saudi government and other official bodies in Saudi?
	The Saudi Building code discuss or relate to the cultural needs of the Saudi population and their unique cultural characteristics
	Design firms stick to and follow the Saudi Building code

Environmental Factors

Rating of Agreement Result from Round 1	Environmental Factors
High	Energy Saving
	Thermal comfort
	Thermal Insulation
	Affordability
	Water Conservation
	Site orientation
	Passive Cooling

The Saudi Culture

Rating of Agreement Result from Round 1	The Saudi Culture
High	Courtyards can be used to ventilate the house as well as provide natural lighting to adjacent rooms
	The traditional courtyard was not just an architectural element. It had social impacts as well. For example a gathering place for the whole family

Rating of Agreement Result from Round 1	The Saudi Culture
Medium	Passive cooling can be achieved utilizing the techniques behind vernacular elements such as the wind towers.
	Mashrabiyas can be designed in an efficient and modern way and can be incorporated into the design of a Saudi house.

Privacy in the Saudi Culture

Rating of Agreement Result from Round 1	Privacy in The Saudi Culture
Medium	Adopting the concept of the courtyard and applying it to the design
	Enforcing the use of landscaping on the exterior parameters of the house and it must be at a certain height that gives privacy to the inhabitants from the eyes of outsiders.
	Each block of a Saudi neighbourhood should have a common area to use for gathering and parties, and leave the house for personal and family use.
	Utilizing the Mashrabiyas and covering exterior windows with them
	Provision of clear-story fenestration along the room walls instead of typical windows
	Designing the house entrance with an L shaped entrance corridor

Affordability

Rating of Agreement Result from Round 1	Affordability
High	The Saudi government should present affordable housing projects
	Materials that will be used in sustainable houses need to be sustainable from the fabrication to demolition
Medium	Closeness and availability of public transport can have a great impact on the sustainability of a house
	Renting a sustainable house can be affordable to Low and Mid-Income families

Thank you for completing this questionnaire. The time and effort that you have spent is much appreciated.

With Best Regards

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Appendix E: First Publication (17th PRRES Conference)

17th Pacific Rim Real Estate Society Conference
Gold Coast, Australia
16-19th January 2011

Challenges Facing Sustainable Housing in Saudi Arabia: A current study showing the level of public awareness

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Abstract

Sustainable housing implementation requires strong support from the public, government and the housing industry. Lack of public awareness and understanding of the language and the meaning of sustainable housing may cause lack of public support. Salama stated that "sustainability or sustainable design is simply a rephrasing of some of the forgotten values of traditional architecture and urbanism"(Salama, 2007a). This exploratory paper examines public awareness of sustainable housing in Saudi Arabia.

In developing countries, like Saudi Arabia, which have been experiencing a rapid rate of urbanisation, sustainable concept intervention is essential due to the scarcity of resources (Reffat, 2004a). Sustainable building methods include the full use of the site design, passive solar design, natural light and ventilation. This paper reports on an exploratory survey on understanding the potential of the implementation of sustainable housing in Saudi Arabia. The main problem is that more than half of respondents were not aware of sustainable housing. Thus, one of the recommendations from the survey is to educate the public by using local media to inform people of the benefits of sustainable implementation to both new and existing housing stock.

Keywords: Sustainable housing, public awareness, Saudi Arabia

Introduction

Saudi Arabia is a developing country in the Arabian Gulf region that has been growing dramatically over the past two decades. It is estimated that the Saudi population is about 15,588,805 and about 5,258,079 Non-Saudi residents live in Saudi bringing the total population to 20,846,884 in 2003 (Central Department of Statistics-Demogrpahic, 2003). The total land space of the Kingdom of Saudi Arabia is about 1,960,582 sq. km. (climate-zone, 2004). The total owned houses are about 1,526,678 and the total of leased houses is about 1,520,693. (Central Department of Statistics-Demogrpahic, 2003). According to the UNICEF, 82% of the population is urbanised (UNICEF, 2010).

The urbanisation rate of Saudi Arabia has been high, thus the country faces significant urban challenges today. “Developing countries today face greater urbanisation challenges than developed countries faced…. For example, the republic of Korea was 40 precent urbanised in 1970 and 78 precent urbanised by 1990. What took the United States 90 years to accomplish took Korea 20 years and Brazil 30 years” (Henderson, 2002a). As growth in Saudi Arabia is estimated to rise in the coming years, the cost of living will also escalate accordingly. Henderson emphasised this point by stating “Although bigger cities offer higher productivity because of scale economies, residents of bigger cities are burdened with higher costs of living- for housing, food, public utilities, commuting, and so on” (Henderson, 2002a).

The high cost of living has discouraged people from implementing new ‘expensive’ sustainable housing. The public perception of this ‘new concept’ is that it is expensive, and some of the public are still not aware about this ‘new concept’.

"Although concerns are sometimes voiced about the initial cost of green projects, the financial benefits are remarkable in the long run" (Cityscape 2010). Housing industry/professionals have some knowledge about new concepts of sustainable development. Munton in Eden (2000) argues that "it will be the local responses to this international call to arms that will determine its success or failure as a practical programme" (Eden, 2000). Eden argues, "The interconnections between local governance, the planning process and citizen involvement are critical to the sustainability programme. To enhance these interconnections, we must consider how the local public views sustainability and why they should want to participate" (Eden, 2000). In terms of Saudi Arabia, this is no easy task. In the 1930's many Saudi people lived in tents, while today most live in modern houses. Convincing this population that a sustainable scheme should be applied to the housing sector is a significant challenge.

It is the aim of this preliminary paper to demonstrate the state of sustainability in the housing sector (especially new housing) in the Kingdom of Saudi Arabia. The paper also investigates public knowledge and public awareness regarding this issue. Since the Kingdom of Saudi Arabia is still under development, it's much easier to apply the concept of sustainability to new construction rather than demolishing old buildings or retrofitting existing buildings.

Current Challenges on Sustainable Housing in Saudi Arabia

Climate Challenges

Saudi Arabia faces environmental challenges caused by climate. The climate in Saudi Arabia is generally harsh, dry desert conditions with extreme temperature differences ranging from -11^{o}C to 51.1 ^{o}C (Piccolo, 2010). Saudi Arabia and any Arabian country, such as Egypt, share the same climate conditions and culture. The climate of Upper Egypt is a hot, arid zone, with a large difference between day and night temperatures (Fathy, 1973, 45). Another challenge that faces Saudi Arabia and other Arab countries is the scarcity of water. "Many Arab countries are reliant on non-renewable groundwater supplies to augment their scarce water supply in order to respond to growing demand." (Swain, 1998). In addition, due to the staggering increase in demand for water in the Gulf Coast Countries (GCC), and extremely limited conventional water resources such as fresh surface water and renewable groundwater, alternative sources such as wastewater reclamation and desalination have been adopted since the 1960's (Stensgaard, 2008). "Today, Saudi Arabia accounts for 4.5 hector of ecological footprint per person, or roughly twice the world average, and are ranked in the Top 20 most environmentally challenged countries in the world" (Al Fadl, 2010a).

Rapid Growth Challenges

In developing countries like Saudi Arabia, which experience such a rapid rate and ratio of urbanization, government departments should implement the concept of sustainability and enforce laws and regulations. In the case of Saudi Arabia, as well as many other developing countries, economics is not the only issue. The quickly diminishing availability of resources must also be considered. Potential methods that may be applied to sustainable housing in Saudi Arabia include the full use of the site design, passive solar design, natural light and ventilation.

Society can benefit greatly from increasing urbanization, particularly if that urbanization occurs at a high rate in a short time span. Consequential to the high rate of urbanization inflicted upon Saudi Arabia within such a short time span, we are witnessing many negative afflictions to the country. Henderson (2002) enlightens us that countries currently undergoing urbanization developments and expansions are facing more challenges than did those countries, which are considered already developed during their years of development and expansion. He gives the example of Korea, which was "40 precent urbanized in 1970 and 78 precent urbanized by 1990". His conclusion results in the mathematical deduction that it took Korea only 20 years and Brazil only 30 years to accomplish the percentage rate of urbanization, which took the US to establish in a 90-year span. Consequentially, taking into consideration the estimated growth in Saudi Arabia to rise in the coming years, costs of living will also escalate accordingly. Henderson emphasizes on this point by his reasoning that expenses for residents of larger municipalities are higher due to higher costs of living, including but not limited to necessities such as food, housing, public utilities, transportation, etc. He also mentions that these higher expenses are not weighed off in equal balance with higher productivity, as can be found in such metropolises. (Henderson, 2002b).

Rapid growth in cities around Saudi Arabia has led to several dilemmas that have risen from the late 1970's during the "oil boom phase" (Garba, 2004, 593). The resulting problem due to the immense growth of that period was that the demand for services from residents was much greater than what the government could respond to. Gamboa suggests, "One of the facilitating factors to the city's growth is the use of no-interest loans."(Gamboa, 2008, 1). As an example of how the rapid growth took place in Saudi Arabia, the capital city of Riyadh will be discussed here. "Riyadh is one of the fastest growing cities in the Middle East." At the population rate of less than 15,000 at the turn of the twentieth century, Riyadh currently (as of 2004) has a population of nearly 4 million, with the projection of expanding to around 10 million by 2020.(Garba, 2004, 594). Garba examined the state at which Riyadh has grown by stating "The city now covers an area of 1782km^2, made up of 1150km^2 of Phase One urban boundary area and 682km^2 of Phase Two urban boundary area"(Garba, 2004, 601). Gamboa agrees with what Garba states as facts and illustrated this by saying "The Saudi government saw that low- to no-interest loans allowed for even small developing firms to expand as far as necessary to help the city's growth from a 1 square kilometre medina to a 3,000 square kilometre metropolitan zone in a little under a 100 years" (Gamboa, 2008, 1).

Tremendous challenges of management for the public sector often accompany urban growth, and in particular when that growth is unusually rapid. The necessity of insurance of the expansion of services to meet the growing needs of the growing population, in addition to the need to ensure that growth and development occur in an orderly and sustainable fashion, are the two basic elements from which these challenges emerge.(Garba, 2004, 593). One of the challenges that stood in the face of planned development was that there was no initiation of defined boundaries for the city, nor laws against those who penetrated the city boundaries, as stated by Gamboa: “The growth of the city beyond the city’s original walled-medina left an infinite amount of space for growth, that in turn created several barriers for developing proper services for its residents”(Gamboa, 2008, 5). This rapid growth took place in Riyadh for one reason. “The central government adopted a policy of giving interest free loans through the real estate development funds and also giving land to citizens free of charge.” (Garba, 2004, 604). As a result for this vast urbanization “Riyadh has transformed from a tribal settlement of about just a square kilometre to a city of 4 million in population occupying an area of more than 1600km^2.”(Garba, 2004, 603).

Privacy Challenges

Privacy, or rather the breach of it, is the main issue that residents in Riyadh are dealing with today. This is the result of lack of proper building codes preventing the building of high-rise buildings in close proximity to low-rise private homes. This has caused the residents of homes to suffer a breach in their privacy, something, which is, accentuated even more in the region because of the prohibitions on this imposed by the religion and culture. This problem is what Gamboa discussed by stating “The proximity of multiple-story complexes to these homes creates social and religious conflicts of privacy widely practiced in the MENA” (Gamboa, 2008, 9). Unplanned distribution of the residential areas has been the instigating factor resulting in a potentially dangerous mixture of foreign single labour forces living in or nearby previously designated family residential areas. This has led to many serious security issues across the city of Riyadh in addition to the rest of the

Kingdom. Gamboa argues this point and states, “While many of residents of Riyadh enjoyed the living styles of detached single family dwellings, many of the foreign workers would rather live in densely-populated apartment complexes” (Gamboa, 2008, 8).

Developing countries such as Saudi Arabia are faced with the predicament of rapid urbanization. It will take those countries collaborative efforts to eliminate what rises from the rapid growth in urban areas. In conjunction with what is stated above regarding the city of Riyadh, other cities from all developing countries suffer from the same problem. However, the developing countries were growing at a much slower pace, hence the problems occurring from the rapid growth were more manageable.

Application Challenges

The application of sustainability to a building is a complex process, not just using new ‘sustainable’ material. For example, using an environment friendly sheet of glass on an Arabian rooftop where the temperature can reach 51^{o}C is not sustainable. (Reffat, 2004a, 2). An innovative concept for sustainable housing has risen, but a vast majority of the public are still unaware of this new possibility. The sheer new-ness of this concept to the public has been perhaps the greatest deterrence, magnified by the perception of it being expensive. However, among housing industry professionals in Saudi Arabia, awareness of this innovative concept on sustainable housing and economical development is on the rise. Eden (Eden, 2000, 114) argues that a critical element in the sustainability program is the interaction between local governments, planners and the citizenship involvement in the planning and implementation stages. He goes on to remind us of the necessity to explore how the citizenship views sustainability and how they are willing to participate in the implementation, in order to coordinate cooperation between the sectors. With the large estimated population in Saudi Arabia, it is no easy task to apply a new concept to a country that has developed from living in tents in the 1930's to having a sustainable scheme applied to the housing sector and convince them that this the right way.

Sustainable housing implementation requires strong support from the public, government and the housing industry. However, the public does not understand the language and the meaning of sustainable housing. Salama (2007b) stated, "Sustainability or sustainable design is simply a rephrasing of some of the forgotten values of traditional architecture and urbanism".

How can sustainability be achieved in Saudi Arabia?

Sustainability in developing countries can be achieved for new construction with collaborative agreement between the government and the stakeholders. "Key Saudi developers are looking at sustainable construction as a key option and with increasing political interest, it is only a matter of time before green guidelines become mandatory" (Al Fadl, 2010a). The construction industry complains on "the lack of resources to invest in the technological changes required for the sustainable application and also their profits will be reduced" (Reffat, 2004a, 3). "According to a report published by the US Green Buildings Council, a green building on an average saves 70 per cent electricity, 50 to 60 per cent of water and 36 per cent of energy" (Cityscape 2010). With this statement in mind, homeowners, investors, developers and all stakeholders in the housing industry should think more seriously about applying the concept and methods of sustainability to reduce the running costs of a house. Reffat (2004a, 7) list primary concerted actions that should be implemented by the stakeholders to pave an appropriate road to sustainable construction in developing countries include:

- Create an advisory stakeholder council Government.
- Raise awareness among government officials and politicians.
- Adopt a regulatory framework for sustainable construction.
- Introduce compulsory continued professional education.
- Provide funding to support emerging businesses and innovative technologies.
- Provide funding for training and education.
- Lead by example.
- Sustainable construction is leading to the development of entirely new market niches in terms of services, materials and tools.
- To create a market for sustainable construction, clients will have to develop their understanding of what sustainability means." (Reffat, 2004a, 7).

There are several methods to introduce sustainability to the public and DuPont Chairman and Chief Executive Officer presents some of these methods, which are "six key actions" that could be used to raise public awareness and commitment to both conservation and environmental protection:

1. "The vision is clearly defined by leadership;
2. Assign an "implementer" who will develop systems to ensure implementation of the vision and objectives

3. Set goals so that everyone involved has something against which to measure progress
4. Hold strategic reviews with key organizations to discuss their role in achieving the goals; discuss potential roadblocks that might impact success
5. Develop awards and recognition to highlight key programs and significant accomplishments
6. Form relationships with key NGOs and other external groups." (Holliday, 2007).

The government, developer, designers, landowners, and the general public who are affected by the construction can form stakeholders in the housing industry. Miranda states "Governments are the ones to initiate changes with the development of a legal framework to encourage the application of appropriate standards and procedures. It is known that unless pressured, the construction industry will not introduce the required adjustments. A key factor is to change the way of thinking of private sector professionals and of the public in general. They need to realize the benefits and advantages of a built environment which is safe to both nature and to the people." (Miranda & Marulanda, 2001, 4). "In most countries there are financial incentives to retrofitting or building using 'green' principles that business owners should take advantage of. Or soon legislation will force the issue." (Cityscape 2010). In contrast to the fact that it is the responsibility of the governments to implement regulations ensuring that sustainable projects are initiated, governments in most developing countries have yet to consider the magnitude of the issue; hence external governments influence developing countries governments. Miranda supports this when she states "The results of urban development in third world countries show that sustainable construction and sustainable development are not yet a priority. This is a concept managed by professionals in certain fields and only recently have governments begun to pay attention to it, due more to international pressure than to internal conviction." (Miranda & Marulanda, 2001, 3)

Many architects and designers agree to the fact that traditional architecture or vernacular architecture achieved sustainability more efficient than modern buildings. This was because people several decades ago did not have the luxury of modern reflecting glass, so they built their windows looking inwards into a courtyard in the centre of the house, which did not omit direct sunlight into the house, but instead it omitted natural light with natural air ventilating the house. Another method that was used in traditional houses was the use of thick mud walls that kept the temperature of the house warm during winter and cool during summer. This act is achieved in modern buildings by insulation but it does not achieve the same aesthetic atmosphere as it did in traditional buildings.

Solutions

Site design and layout is one of the most important aspects when implementing the concept of sustainability. The project starts with a site that most positively will have terrain and/or some natural landscape, and what most people do when they first get their hands on a piece of land is strip it from its natural envelope and level the site for a new project. Sustainability starts in a project from the site design and how to incorporate the building with the site and it natural envelope. Reffat tells us that "the most environmentally sound development is one that disturbs as little of the existing site as possible" (Reffat, 2004c, 3). He also tells us that an ideal site plan is one that is developed based on site data covering the larger macro-environment and includes historical and cultural patterns of the community.

One way to solve the problem of how to use daylight as a form of sustainable integration in the building is by combining daylight with electrical lighting and preferably at the same location. In this situation day light can be used during the day with possibly a dimmed electrical lighting support and then can be fully electrical during the night. “Day lighting design is the use of good design sense, not the application of technology. Day lighting design is the pattern of light in the sky told as a story in the building's form and details.” (Loveland, 2002, 31).

Passive solar design is one of the most efficient ways to reduce the use of non-renewable energy. “The basic idea of passive solar design is to allow daylight, heat, and airflow into a building only when beneficial. The objectives are to control the entrance of sunlight and air flows into the building at appropriate times and to store and distribute the heat and cool air so it is available when needed.”(Reffat, 2004c, 5). There are many ways that passive solar design can be implemented into a building to make it sustainable. According to Reffat, passive building design begins with study of the building site, day-lighting opportunities and the whole building concept. From there building systems are considered. Nearly all elements of a passive solar design is for more than one purpose: landscaping beautifies while shading or promoting good airflow, window shades are a decorative asset while providing interior shade, a sunny room is a bright space as well as good task light, etc.

In Saudi Arabia approximately more than 75 precent of the year, sunlight is clear and can be harvested if designed daylight systems are integrated into a building. Abraham in Reffat (2004b, 5) says that “day-lighting significantly reduces energy consumption and operating costs”, so much so that a properly designed day-lighting strategy can save 50 to 80 precent of lighting energy. Following are some of the principles that can contribute to this:

- “Avoid direct sunlight on critical tasks.
- Bring daylight into the room from a high location, such as windows, skylights, roof monitors and clerestories, the windows being the less effective of all because of the great brightness levels they provide.
- Filter daylight using trees, plants, draperies and such.
- Bounce daylight off of surrounding surfaces by means of light shelves, blinds and such.
- Integrate daylight with other building systems and strategies which work coinciding with the building system or design, not against it”. (Reffat, 2004c, 5)

Methodology

This paper uses data, which was collected from a web-based survey that was distributed on Saudi residents. The reason for using this web-based survey is because it can be handled remotely outside Saudi Arabia. The survey consists of quantitative and qualitative data that will be analysed in separate sections. The targeted participants were from the Saudi Council of Engineers. The SCE is a society that groups all fields of engineers that include Architecture, Civil engineering, urban designers and other fields of engineering. The reason for selecting the SCE is because there is no other society that groups all types of engineering and can be targeted for research purposes that are currently present in Saudi Arabia. All architects and designers are categorised as engineers in Saudi Arabia and are members of the SCE. The web-based survey was designed in Arabic language to reach wider Saudi participants. The total number of participants was 693. The majority of participants of this survey are male, consist of 620 male and 73 female. Figure 1 shows that the majority of participants are between 21-40 years old (77% of total participants).

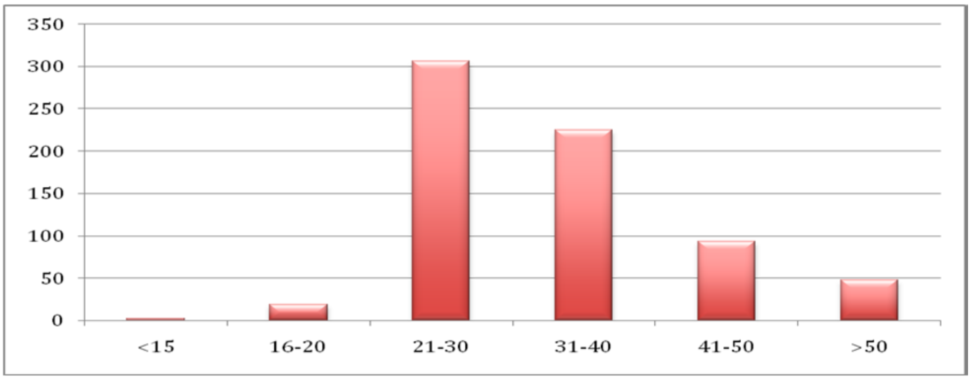

Figure 1 Age Distribution

Quantitative data analysis

In general, over 52.2 precent of the participants are not aware on this issue and have not heard the term "sustainable housing" before participating the web-based survey. However only 3 precent of participants said that sustainable will not save money. More than 70 precent of participants agreed that sustainable housing will save energy bills (electricity and water).

Only 21 precent of the participants thinks that there are sustainable houses in Saudi Arabia. The rest of the participants do not know or do not think there are any sustainable houses in Saudi. However, over 71 precent would participate to retrofit their house to be sustainable when possible. Figure 2 illustrates the respondent's willingness to participate in retrofitting.

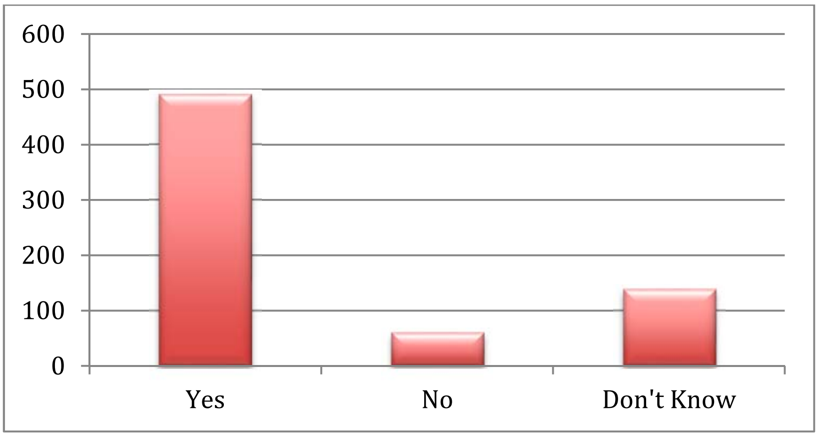

Figure 2 Participation to retrofit to sustainable buildings

Table 1 compares the importance of sustainable housing according to participants. Majority of participants suggested building new sustainable housing is very important (nearly 50 precent). The participants have a range of opinions in regards to retrofitting existing buildings to become sustainable. As mentioned in the literature review, majority of people live in the rental housing and mixed responses on the retrofitting existing buildings between investors and users (renter) spread their opinions.

Table1 Market acceptance on sustainable housing

	Not Important	**Somewhat Important**	**Important**	**Very Important**
Building Traditional Houses	27,0% **(187)**	39,4% **(273)**	25,4% **(176)**	8,2% **(57)**
Building Sustainable Houses	5,1% **(35)**	13,7% **(95)**	31,9% **(221)**	49,4% **(342)**
Retrofitting existing buildings to become sustainable	11,7% **(81)**	25,3% **(175)**	33,0% **(229)**	30,0% **(208)**

Although nearly 80 precent agree to use natural light, a large number of participants still do not agreed to use active sustainable features. Sixty percent of the participants agreed to switch from non-solar heating water tanks to a solar heating system. The participants are split into half-half on their opinions to collect and reuse rain water . This is mainly because of the lack of rain in Saudi in general and the use of water collecting tanks would be useless in a desert climate region. Public awareness on sustainability features, such as solar heating water and rainwater tanks need to be investigated in future studies that consider culture and local climate.

Outcomes of Quantitative Data

- There is a trend in Saudi Arabia that is moving towards sustainability but with the lack of knowledge that the public have of this concept then the application of it would be difficult.
- It is easier to apply sustainability to a developing country than in a developed country because in a developing country the construction is still under way and can be applied while the construction is still underway.
- Methods that can be used in Saudi buildings include the use of the site design, the passive solar design, the use of daylight and the use of natural ventilation.
- The main outcome from the survey that was distributed on Saudi participants was that there seems to be a general lack on knowledge of the concept and how it can be applied in real life.
- After the participants were introduced to the concept of sustainable housing, more than 71% were more than satisfied to apply it to their existing houses and those that are still under construction if it was presented to them

Qualitative data analysis

Responses to questions asked were used as qualitative data. The analysis of those questions is shown in this section of the paper. One question focused on the participants' understanding of sustainable housing. Of the 693 participants, the following responses were useful for this paper. Most responses were inadequate and some were repeated. The responses were then combined in the following groups; education, design, regulation and cost.

Education:

- "1- it is a required technique for the future. 2- it should be introduced to the public. 3- it should be included in local building codes" (Respondent 1)
- "It is a good idea, yet it has to be accompanied with a change in people thinking." (Respondent 2)
- "I think sustainability has a great benefit on the environment and humans. However, it should increase people's awareness about this term to gain maximum advantages." (Respondent 11)

Design:

- "I really encourage adopting sustainability at the outset of the project life cycle. In most cases it is feasible to change current buildings to sustainable ones. However, this can be considered in the maintenance process, by fitting new systems, instead of defected ones, that are more sustainable." (Respondent 4)
- "Also the environment that it is intended for (i.e. Saudi Arabia is very hot and very shiny state) therefore using sun light to light the house will be offset by having to install a huge HVAC system to cool the house." (Respondent 2)
- "It is imperative that we, in Arab countries start considering sustainable houses when we build our homes. I'm strongly in favour of green houses and sustainable systems" (Respondent 5)
- "The idea of sustainability must be applied in all areas and not confined to the field of architecture. Sustainability is to build for the long-lasting, taking into account the materials used such as building materials or the techniques used, such as air conditioning, lighting and others. Sustainability is a broad concept and all countries in the world, especially the developed countries take into account this concept and apply it in construction, transport, education, management and others." (Respondent 6)
- "The need to find a healthy environment, sound and atmosphere appropriate for the family within the home requires us to take these techniques to result in positive effects on community family - and the ensuing generations of sound, which in turn promoted the community, and these are a series of interrelated construction requires treatment basis, and this vision, I think it is necessary to test, develop and

create other solutions that are compatible with our society to address the physical and social environment in the cities of the Kingdom." (Respondent 7)

- "I totally agree to apply this method on Saudi's buildings such as the use of solar energy because it is available a lot there." (Respondent 11)

Regulation:

- "I wish houses could be built this way in Saudi Arabia, and I also wish it was mandatory and enforced and an essential part of the forthcoming Saudi building code. But before that awareness is necessary to convince owners to go that way. All existing public buildings should be refurbished and made greener and cleaner." (Respondent 8)
- "I think that the idea of sustainable buildings should not remain an idea but it must be included in the Building Code and applied gradually so as not to become a choice but become a necessity for the design and construction. I think that the main role here is located on the engineering bodies and governmental institutions to try to enforce these systems on each of the works in construction" (Respondent 9)
- "It should be promoted by all involved parties; government agencies, designers, contractors, suppliers, and press." (Respondent 1)
- "I think it's time to be a gesture of genuine, backed by the official authorities in charge of Saudi Arabia to the application of approaches and styles of traditional and sustainable harmony on parallel tracks to improve the environment construction, especially since the demands of life and climate requires us." (Respondent 7)

Cost:

- "I am very convinced of the need to make our houses and structures more and more sustainable. The savings in energy, water, will be tremendous. The quality of life also will be better as we will be more compatible with nature." (Respondent 10)
- "Sun light also can save people money by using it in the day to reduce electricity consumption." (Respondent 11)
- "It is very important to find a way to make our lives better. The principle of using the green house is a must nowadays. That is because the high need of saving in the cost "even construction or running cost" & energy also environmental." (Respondent 12)

- "I am confident that implementing and adapting sustainable houses will eventually reduce the house cost considering the life cycle and will be more environmentally friendly as well." (Respondent 13)

Recommendations from the Qualitative Data

- Introduce the concept to the public by using the local media, newspapers, television and radio broadcast to inform them of the benefits of the concept and how important it is to apply it now while we still have a chance.
- Encourage the government to apply sustainable codes to be applied on current constructions and in future ones and offer incentives to whomever wishes to retrofit their house.
- Regulate seminars and workshops for designers, engineers and any stakeholder in the construction industry to educate them on how to achieve sustainability and how important it is.
- Incorporate local engineering bodies to legislate the implementation of sustainability after it has been introduced to the public and recommend it to the involved ministries to legislate it regionally on the whole Kingdom.
- Migrate some of the construction methods from traditional architecture of the Kingdom to new modern construction buildings because it is evident that the recent method of building is costing too much on energy bills.
- Introduce sustainability courses to the public so that if any one who is interested to learn more, he/she can enroll and educate him/her self.

Conclusion

Saudi Arabia is one of the developing countries in the Gulf region and the implementation of sustainable housing is easier because the country is still under development and the construction rate is higher than ever. The use of local materials and knowledge of how the historical buildings were built must be considered together. It is recommended that the use of natural resources, for example solar power is crucial for the success of the application of the concept. Local engineering bodies and the government must work together to legislate the concept of sustainability. Understanding and knowledge of the community is also crucial to the successful implementation of the concept. It is recommended that further research of public awareness needs to be conducted to apply sustainability in a context where the majority of residents are renters.

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Appendix F: Second Publication (STDCC 2012 Conference)

Analyzing the Literature for the Link between the Conservative Islamic Culture of Saudi Arabia and the Design of Sustainable Housing

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Abstract

Saudi Arabia experiences housing shortage for mid and low-income families, which is caused by rapid population growth. This condition is worsened by the fact that the current housing supply has problems in meeting both sustainable requirements and cultural needs of those families. This paper aims to investigate the link between the unique conservative Saudi culture and the design of sustainable housing, while keeping the housing cost affordable for mid and low-income families. The paper is based on a review of literatures on the issues of the Islamic culture and how can they be integrated into the design process of a Saudi house. Findings from literature reveiw suggest several design requirements for accommodating the conservative Saudi Culture in low cost sustainable houses. Such requirements include the implementation of proper usage of windows, and house orientation with a courtyard inside rather than facing the main street will provide natural ventilation while maintaining privacy. The main contribution to the body of knowledge is that this is a new approach to sustainable housing in Saudi Arabia considering not only energy use and architectural design issues but also socio-cultural issues as an essential part of sustainability.

Key Words: Saudi Arabia, Islamic Culture, Saudi Culture, Sustainable Housing, and Privacy.

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1.0 Introduction

Housing is an essential need for human life (Gamboa, 2008, p. 4). In traditional societies, housing simply meant shelter. In these societies, housing was emphatically efficient, compatible to the surrounding environment and socially fitting (Mubarak, 1999). In other words, shelter had a close relationship with survival. But with the development of human society into what it has become today, we find that housing and land have evolved into something more than a basic necessity for survival. They have become somewhat of a statement of social stamina instead. People perceived land and housing as social resources rather than market commodities. As a result, the provision of housing has become more complex rather than easier. Various factors dictate efficient housing designs that can cater for both cultural and social needs. Some factors include economic resources, government policies, and the level of institutional and technological advancement, among others (Mubarak, 1999).

In the Kingdom of Saudi Arabia, economical developments due to the discovery and commercial exploitation of oil in the 1930s coupled with the rising market demand in the 1970s transformed traditional societies into lifestyles similar to those in many developed societies (Mubarak, 1999; Sidawi, 2008). As a result, population in Saudi Arabia's main urban centers increased tremendously, thereby causing fast urban growth. The Saudi Arabian cities are the fastest growing cities in the Middle East (Gamboa, 2008, p. 4). Within a period of 42 years (1950-1992), Saudi Arabia's urbanization level advanced from as low as 10% to 75% (Library of Congress, 2011). Cities such as Riyadh grew tremendously, hence bearing both sweet and bitter fruits for Saudi Arabia (Al-Hemaidi, 2001; Gamboa, 2008). Results from the 2009 census reveal that the kingdom had about 28,686,633 inhabitants. Among these, Saudi nationals accounted for 80.5%. (CIA World Factbook, 2011).

This tremendous growth caused strain in various sectors of the Saudi Arabian economy (Mubarak, 1999). According to Mubarak, the first sector to experience this strain was the housing sector. The tremendous increase in demand for new and advanced housing units prompted the use of modern architectural construction methods and design styles. Mubarak suggests further that the prominent modern styles included the western-styled Villa and multiple story apartments. However, the problem of housing shortage persisted, especially among low-and mid-income earners (Gamboa, 2008, p. 4). According to Gamboa, even when one managed to secure housing, it was neither sustainable, nor efficient in the provision of cultural needs of the occupants. And according to Hamed (2003) designing sustainably is no longer a luxury addition to a building, it is now vital to the survival of the present generation and those yet to come.

Through literature, this paper establishes the link between Saudi Arabia's unique conservative culture and sustainable housing design while maintaining housing costs affordable to mid and low-income families. This study will be looking at only the multifamily detached housing units. It explores various literatures on Islamic culture issues and the ways in which designers can integrate them into Saudi house design. Some of the literature that will be investigated include Daneshpour, A. 2011, El-Shorbagy, A.M. 2010, Hamdy, K. 2000, Hamed, S.E.A. 2003, and Kamaruzaman, J. & Siti, A. 2011.

Various architectural elements were explored as to how they can be incorporated into the design of a Saudi house that can help improve the sustainability of the house. Such elements that will be discussed include the courtyard, windows and where they are positioned and the use of the Mashrabiya, segregation in design and the use of natural elements such as natural lighting and natural ventilation. Some of the literature that will be investigated regarding these issues include AL-Rimmawi, H. & Bhardwaj, S. 2007, Aleqtisadia 2009, Alghamdi, A. 1995, Mabrouk, M. 2006, Mahmud, S. 2009, Samuels, W. 2010, And Sidawi, B. 2008. Finally, recommendations are offered for possible design requirements to be incorporated into the Saudi building sector, which can accommodate the conservative culture of Saudis in sustainable low-cost houses.

2.0 Conservative Islamic Culture of Saudi Arabia and Sustainable Housing Design

For a long time, the delivery of housing products to Saudi residents has utilized a traditional approach because demand for housing in Saudi Arabia emerged due to variation in level of income and population growth (Mahmud, 2009, p. 69; Sidawi, 2008). It regards cost reduction as the main factor and disregards the other factors (Salama, 2006, p. 67). According to Sidawi (2008), the designers have neglected the Saudi's cultural norms, lifestyles and traditions. Sidawi (2008) suggests that incorporating these dimensions into housing design decreases the overall cost of the product, its lifetime cost (maintenance and running cost, renovation and alteration expenses). This would affect property life and the user's life positively. Therefore, housing designers bear the responsibility of providing tailored and sustainable housing that meets user needs, while the users bear the responsibility of using the houses in a sustainable manner (Gamboa, 2008, p. 4). This section explores Saudi Arabia's Islamic culture, linking it with sustainable housing designs.

2.1 Conservative Islamic Culture of Saudi Arabia and Dwellings

The Saudi culture is defined by the teachings of Islam and is governed by what the Qur'an and the Hadith (Sayings) of the prophet Mohammed (Peace Be Upon Him) state. In Islam, the Holy Quran and the Sunnah (Prophet Mohammed's deeds and sayings) are the guidance for all Muslims in every aspect of their daily life. Therefore, it is imperative that what is learned from the Holy Quran and the Sunnah is reflected by the essential design of the Muslims' houses.

The culture of Saudi residents is a family oriented culture, where three to four generation may live under one roof. The elderly are respected and are considered the wise members of the family and are also considered the head of the family (North & Tripp, 2009). With this multigenerational household in mind, it is evident that the Saudi house would be larger in scale as opposed to those where a single family live in a two bedroom unit or similar.

Segregation is also an important Muslim value, which house design should incorporate. Muslim culture advocates for segregation, especially women from public life in the streets. This fact is true in Saudi Arabia where the segregation between male and female sections in a house is typical and mandatory to follow the Islamic ways of living.

According to Mahmud (2009, p. 4), privacy is paramount in the design of housing for occupants ascribing to the Muslim culture. In this culture, privacy, especially for women is extremely imperative. "Privacy in Islamic culture defined in three main areas: Privacy between the neighbors dwelling as well as between the individual dwelling and the street, Privacy between the sexes and Privacy between individual family members of a dwelling." (Daneshpour, 2011).

2.2 Conservative Islamic Culture of Saudi Arabia and Mosque Community

The cultural and religious background of a person determines how far they would live from a Masjid (Mosque), which also affects the design of a Saudi house in many ways. Since it's obligatory for a Muslim to pray five times a day, closeness to a Masjid became a requirement in the Saudi culture. Traditional neighborhoods were all centered on a central large Masjid, which was most generally surrounded by many of the village or town's needs. The Masjid grew from simply a center for worship, in to the place to discuss important issues or find access to many of the townsfolk's needs. Figure 1 shows a satellite image taken from the city of Riyadh where it shows how many Masjids are in a small area of the city, hence this illustrates how living near a Masjid is significant to the Saudi population.

Figure 1 the importance of a Masjid in a neighborhood in Saudi Arabia

Traditionally, one large Masjid would suffice for the whole town, which had several advantages. One main advantage was that the whole town could see each other and asks about each other's wellbeing. Another advantage was that it became a place to make announcements to the local community as they all prayed in the same Masjid.

Nowadays, one can find several Masjids in one square kilometer. This has more disadvantages than people would realize. One of the many disadvantages of having so many Masjids in one neighborhood is that people don't interact with one another as they used to in previous times. Another disadvantage is that there is no regulations against how many Masjids can be built in one neighborhood, which affects the interconnectivity of the residents of any neighborhood.

2.3 Conservative Islamic Culture of Saudi Arabia and the Environment

The environment is a sensitive component in Islam (AlGhamdi, 1995). As a result, the Muslim culture requires housing designs that show concern for the surrounding environment (Syme, et al., 2002). According to Syme et al (2002), Muslim culture requires every believer to show respect for benefits acquired from animals, land and forests because they come from Allah's blessings. In other words, a believer should not abuse natural resources through the direct or implied impacts of their actions (Swanson, 1996). According to Swanson (1996), Islam is completely adamant that people should not utilize natural resources to the resource extent alone. In fact, utilizing a natural resource to the resource extent alone is tantamount to committing sin. Thus, it is important to protecting and keeping the environment for only the benefits that Allah exclusively intended for Islam.

According to Champan et al. (2000) "Because Islam is a comprehensive way of life, with God-consciousness permeating all of human activity, whether it be business, education, social conduct, or science, religion and science become inextricably bound in God's creation. Thus, from an Islamic perspective, the environment, consumption, and population are no different whether viewed from a religious or a scientific angle". Hamed (2003) further enforces Champan's et al (2000) statement by stating "Islam as a paradigm and a system of life provides a distinct view of the role of man on earth and of the ownership of resources. Associated with this view are sets of unique values that are different from those of the West and other world cultures. Also, Islamic jurisprudence provides specific laws and standards that govern the management of all environmental resources".

In the Muslim culture, light is a symbol of divine unity. The Quran itself describes God as the light of the earth and the heavens (Qur'an Nur

24:35;(Kamaruzaman & Siti, 2011, p. 46). Just as light gets nothing from a shadow, the reality of things extends to the sharing of the light of existence. Viewing light directly creates a blinding effect. However, people use harmony in colors to define nature, which, in itself carries every visual phenomenon. Therefore, Muslim artists aspire to transform their designs into vibrations of light. In architectural designs incorporating Islamic culture, light plays a decorative role by creating patterns or modifying various elements.

With the religious aspect of the Saudi culture in mind, the designers should incorporate the needs of the Saudi population into the design of their houses. As it is unmistakable that segregation between males and females is obligatory, designers should respect this fact and integrate isolated sections for both sexes so that comfort can be attained for both inhabitants of any Saudi house. Other characteristic of design that originates from a religious point of view is privacy. Although privacy should be achieved in any house around the world, achieving it in the Saudi culture is imperative to the comfort of residents of any Saudi house. Such characteristic can be achieved by designing windows that have Mashrabiyas installed on them or by other means that will be discussed later on. The Mashrabiya is a traditional wooden mesh that is installed over a window, which lets in light and air but gives the inhabitants a well sense of privacy as well (see section 3.3).

3.0 Design aspects for the conservative Islamic culture of Saudi Arabia

This part of the paper discusses some of the design elements that can contribute towards the sustainability of the housing needs of the unique conservative Islamic culture of the Saudi population. The discussion here will focus on the relativity to a Masjid and how to design the neighborhood around it in a sustainable way. Other aspects of design will also be discussed that are vital include achieving privacy, entrances and windows, segregation, the use of natural elements such as airflow and natural lighting and integrating them into the design, and finally courtyards.

3.1 Relativity to a Mosque (Masjid)

As discussed earlier regarding the importance of a Masjid to the conservative Saudi Muslim culture, it is imperative that urban and city planners and architects merge their knowledge and efforts with the city councils to regulate how many Masjids can be built in one neighborhood and how far they should be from one another. One of the many ideas that the Saudi Planning and Rural Affairs Ministry should consider, is to localize one main Masjid for the one neighborhood where the five prayers can be performed as well as the Friday prayer and other religious occasions such as the Eid. This Masjid is located in neighborhood center, which provide all the neighborhood’s needs ranging from government offices to commercial outlets. Therefore, the neighborhood would be intact and the resident in each neighborhood would not have to travel far distances from one side of the city to the other to fulfill his or her needs.

There are many advantages that can be the outcome of such a breakthrough in the Saudi sustainable neighborhood design. One main advantage is that it will immensely reduce the need for using cars and other means of travel because the entire neighborhood's needs are within walking distances. Another advantage is that the whole neighborhood would interact with each other and they will cater for each other's needs because all the members of that neighborhood would be generally informed of any missing need or requirement of their neighborhood.

In utilizing this concept of localization of each neighborhood's requirements and needs, architects and city planners have to consider how to design the Masjid and its location and the surrounding amenities so that it is within reasonable walking distance from the farthest house in the neighborhood. Some design feature have to be considered in order for this concept to triumph, such as the use of shading devices to cover the pedestrian pathways to create a pleasant comfortable environment for the walking neighborhood. This concept would encourage the residents of the neighborhood to go out more often and utilize these walking areas for exercise or to mingle with other members of their neighborhood. But it is vital that all safety requirements must be taken into consideration and implemented into the design for making these neighborhood centers safe and enjoyable for its users.

3.2 Privacy

A typical Saudi home (Figure 2) is designed to be as far away from the public's eyes as possible. "From a Saudi point of view, the ideal home is a self-contained villa away from the peering eyes of neighbors. High walls typically surround Saudi houses. Within the walled area, houses of extended families may be connected to each other in what resembles a walled estate."(North & Tripp, 2009). This is why in any Saudi street the typical skyline would be of high fences surrounding homes, such that the design of the house might not even be noticeable, except from within the boundaries of that fence. Hence, lots of efforts are put into the elevations of a house, but opening an opportunity for great courtyard designs that could be of great value to making the house a more sustainable one.

Figure 2 A typical example of a Saudi villa (Milligan & Gilmour, 2012)

3.3 Entrances and Windows

Privacy is also achievable from the unique design of the entrance (AlGhamdi, 1995). In houses with two entrances, the main entrance should open towards the direction of a courtyard. The other entrance should be the doorway, a key external feature that should be at the ground floor position or level. The entrance preserves the family's privacy by opening into blank wall. This orientation obstructs views from outside into the inside. Figure 3 below illustrates clearly how the concept of privacy was achieved in vernacular houses by having an L shaped entrance that leads directly into a courtyard.

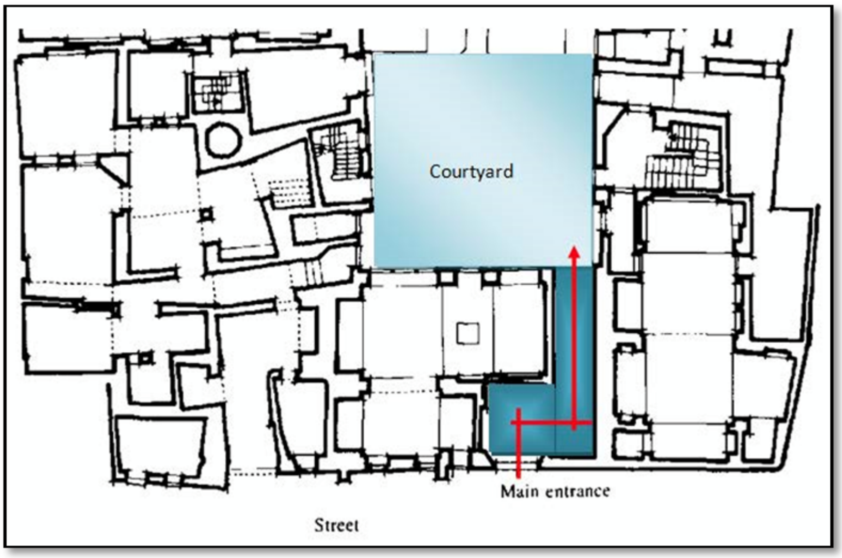

Figure 3 How to design the main entrance in vernacular houses. Obtained from (El-Shorbagy, 2010)

Other architectural elements that can contribute immensely to the comfort of Saudi house inhabitants, is the design and installation of windows that have Mashrabiya installed on them. The Mashrabiya is a traditional wooden mesh that is installed over a window, which lets in light and air but gives the inhabitants a well sense of privacy as well. But according to Samuels (2010) these Mashrabiyas are no longer in use because of its economical constraints to construct and the time span to construct one. Even though of the high cost of constructing a Mashrabiya in the traditional way and the long time span that it took (Samuels, 2010) the use of light-weight material that resembles the traditional material that was used in previous times might prove to be cost effective and worthwhile. Therefore, revolutionizing the concept of the Mashrabiya and considering standardizing its fabrication requirements, could result in more cost effective house construction. This would require collaboration among the stakeholders of housing development. (Figure 4 and 5) illustrate some of the Mashrabiyas.

Figure 4 A façade of a house that utilizes the Mashrabiya (Flickr, 2010)

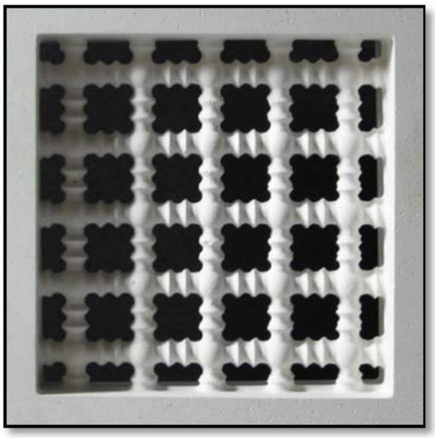

Figure 5 An actual element of the Mashrabiya (Samuels, 2010)

3.4 Segregation

The house design should separate private and public life, maintaining their independence. Alhazmi and Nyland (2010, p. 2) point out the importance of segregation in Saudi Arabia by stating “This phenomenon of gender segregation is central to most people's social, educational and political activities.". To incorporate this belief in housing design, the housing designer should divide the house into three distinct areas: private areas for the inner family members such as the father and the mother, semi-private areas for the whole family, such as the living room. And finally, public guest zones for men. According to El-Shorbagy (2010, p. 15) the traditional Islamic-Arab house layout segregated the house between what is public, semi-public and private areas of the house. Women mainly use the private areas of the house, while men use the other parts. He also adds that the design of the house is an inward looking design where the outside walls are generally bland, which discourage strangers from looking inside. Alhazmi and Nyland (2010, p. 2) agree with El-Shorbagy and state "Saudi social life is divided by men into two separate worlds: the public world and private world. The public world is the area of business and political activity which is the man's domain. The private world is usually considered as a retreat, and sanctuary that man should keep safe and secure".

3.5 Environmental Sustainability

Sustainable housing designs for mid and low-income families in Saudi Arabia require incorporating the elements that were discussed earlier. In addition to those design elements, the design concepts must be pushed more into becoming a green design. And because of the uniqueness of the Islamic conservative culture of Saudi Arabia, it is crucial that designing firms take into consideration the client's needs carefully. One of the primary cost reduction solutions in the design process, that can help mid & low-income families, is to design with Green energy concepts.

Green energy concepts focus on improving the energy efficiency of existing and new buildings (Roberts, 2011). This accompanies the largest, most diverse and cost-effective opportunity in building design and erections. According to Roberts (2011), the design of green buildings ensures that they adhere to specific code. Rating systems for these buildings fall in five different categories: indoor environment, materials, energy, water and site.

Although the technologies and practices adopted by most architectural designers in green buildings differ from one region to another, fundamental principles exist (Kamaruzaman & Siti, 2011, p. 46). For instance, they exist in design efficiency, energy consumption, and water and material use. According to Mahroum (n.d.), green buildings decrease energy consumption by approximately 30%, water consumption by 30% to 50% and 50% to 90% in cost savings. This explains the increasing global pressure on the construction sector. This pressure requires people to use concepts that are not only energy efficient, but also environmentally safe. The existence of regulation frameworks and government incentives has evoked extensive interest on the use of Green building technology (Sidawi & Meeran, 2011). In fact, governments are acknowledging the need to foster construction concepts that are eco-friendly. Such techniques help to: 1) save energy (water and other natural resources), 2) reduce pollution, waste and environmental degradation, and 3) implement comforTable and healthy living environments (Al-Rimmawi & Bhardwaj, 2007, p. 2).

There are serious efforts in Saudi Arabia to develop a strategy that cultivates the green energy concept (AlGhamdi, 1995; Medhat, 2001, p. 142). In 2009, the formation of the Saudi Green Building Council took place (Mahmud, 2009). This was a necessary step because the ecological footprint in Arabia is approximately 4.5, hectares /capita, almost two times the global average. Besides, Saudi Arabia features among the top 20 countries that are most environmentally challenged (Al Fadl, 2010b).

A close analysis of the Muslim culture reveals that green building concept will play a vital role in sustaining the culture. This focuses mostly on their respect for nature and desire to conserve the environment (Hamdy, 2000). The fact that the use of this concept results in cost reduction implies that the houses will be cheap to purchase (Queensland Government, 2009). Thus, the mid and low-income families requiring cost effective housing with elements of the Muslim culture may benefit greatly from this concept. Therefore, the design of residential houses using this concept is a noble idea that may yield maximum benefits to both the constructor and the house occupants.

Designers can use light to integrate a dynamic character to architectural designs; the combination of shade and light (Figure 6) generates conspicuous plane contrasts and adds texture to stone sculptures, as well as brick or stocked surfaces (Hamdy, 2000). The use of light will be a cheap way of providing the best house designs that reflects the Muslim culture. Where natural light is absent, the designers may incorporate the use of artificial lighting elements, but should minimize the final cost to make the houses affordable.

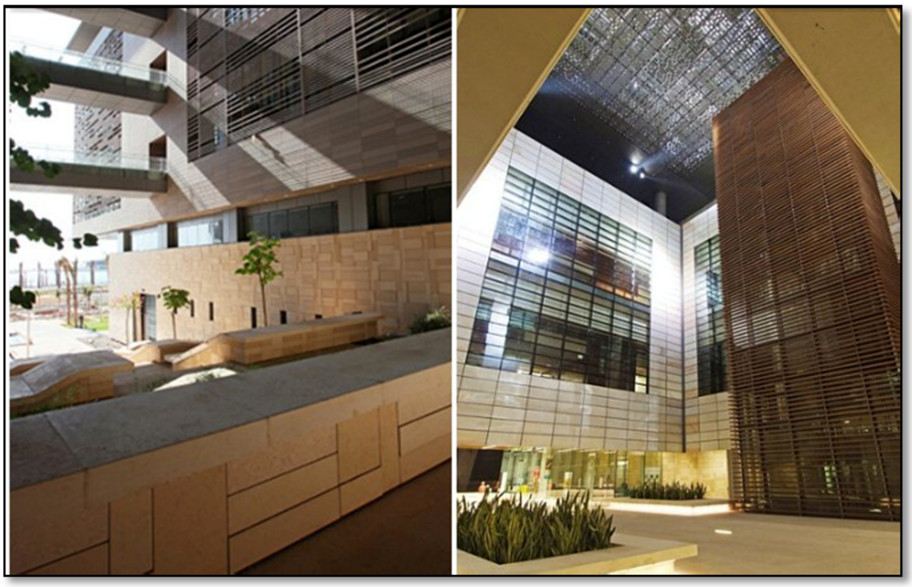

Figure 6 An interior view of KAUST in Saudi Arabia, which illustrates how to utilize light and shade to enhance the aesthetic value of the building (Meinhold, 2011)

3.6 Courtyard Design

The design aspect of privacy necessitates proper use of space and orientation of the courtyard. The courtyard concept was common among Muslims mainly because it satisfied their social and religious needs, especially, privacy. Additionally, the courtyard's arrangements provided their environmental needs. Accordingly, it is vital that sustaining the environment penetrates through the design of the Saudi house, which is evident in the design of the courtyard. Figure 7 below illustrates an old neighborhood in the city of Riyadh and it is obvious that every house had a courtyard.

Figure 7 A layout of traditional Saudi houses showing courtyards in every house (Aleqtisadia, 2009)

The courtyard should face the inside rather than the main street. In vernacular housing designs, features such as high walls on roofs, door and entry area arrangement and windows create the impression of privacy. Most of the spaces should face the internal courtyard to avoid situations where the openings in adjacent buildings face one another.

In the hot dry Arab zones, which form most parts of Saudi Arabia, thermal comfort is a necessity, (AlGhamdi, 1995; Swanson, 1996). As a result, a sustainable house design should cater for this need. Besides providing privacy, the courtyard design should be such that it enhances thermal comfort within the house. The design of the courtyard should facilitate free air circulation through convection (Figure 8). In hot dry weather, the courtyard air, which should be hot due to the sun's heat at daytime, rises, to pave way for cool and dense night air flowing downwards into the court. The amassed cool air within the courtyard penetrates and cools surrounding rooms. The four walls in the courtyard provide shade during the day. According to AlGhamdi (1995), this ensures that air inside the courtyard absorbs heat slowly and maintains its coolness until late hours of the day. To maintain housing costs affordable for low- and middle- income earners, the designer should choose the size and number of courtyards fitting in the available space, and using only the available resources.

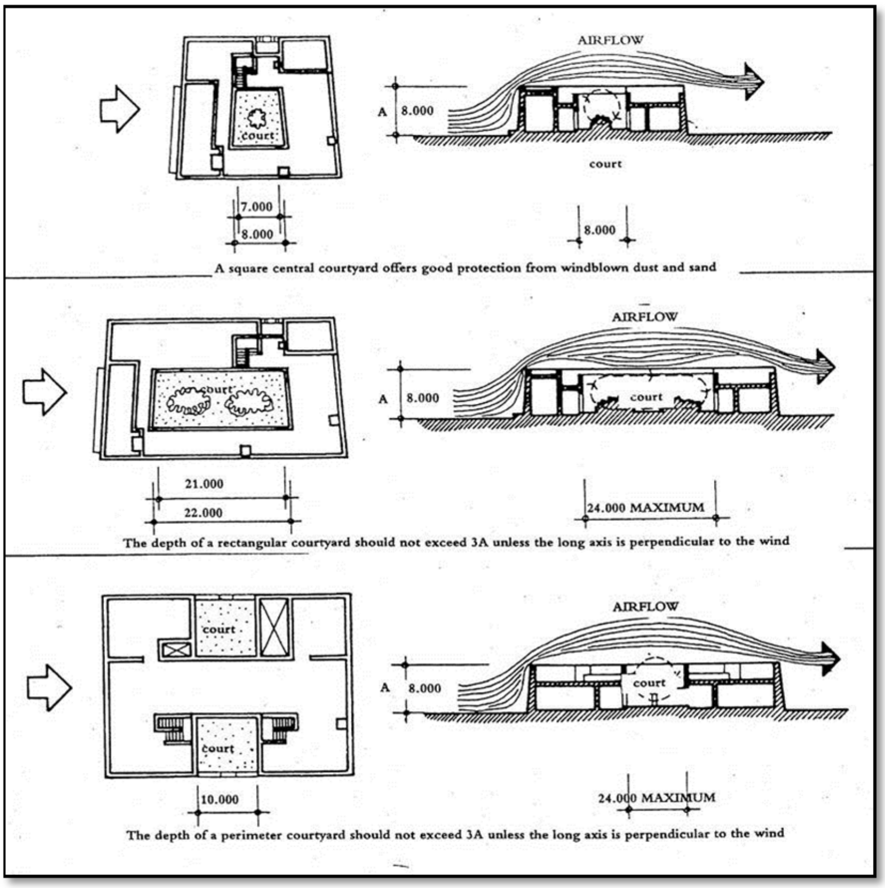

Figure 8 Airflow in a traditional courtyard (Mabrouk, 2006)

4.0 Linking Culture with Design

In this section of the paper, an attempt will be made to link the aspect of the unique conservative Islamic culture of Saudi Arabia and sustainable design. The linkage will be in a tabular format where the sustainable design elements will cross where appropriate with the cultural aspects that are discussed in this paper. The link between the cultural aspects and the design elements will range from high to low according to its importance and relativity. A rating of High means that the relativity between the cultural aspect and the design element are interconnected in a high bonded relationship where each stage of the design phase must adhere to the cultural need of the Saudi resident. A Mid rating means that the relationship between design and culture is moderate but still needs to be addressed to achieve maximum comfort of the residents. A Low rating means that the designer can combine design and culture but it is not as important as the mid and high elements of both categories that are discussed here. In summary, the unique characteristics of the conservative Islamic culture must be included in the design phase of any house to reach the desired comfort that the Saudi family requires. Each designer should familiarize him/her self with the cultural background of each Saudi family they will be designing for because references to what is important and what is not in regards to cultural aspect may differ from family to family.

Table 1 Linking Culture with Design

		CULTURE				
DESIGN		**Multi-generation**	**Segregation**	**Privacy**	**Environment**	**Light**
	Relativity to a Masjid	Low	High	High	High	Low
	Privacy	High	High	/	Mid	Mid
	Entrances and Windows	High	High	High	High	High
	Segregation	High	/	High	Mid	Mid
	Environmental Sustainability	Mid	Mid	Mid	/	High
	Courtyard	Mid	High	High	High	High

It is clear that the strongest link in Table 1 is between the courtyard design and almost all the Saudi conservative Islamic culture aspects. The courtyard design will achieve not only sustainable housing but also meet the Saudi conservative Islamic culture. In addition, other design aspects can be incorporated in the building not just sustainable housing but also sustainable neighborhood center.

5.0 Concluding Remarks

Housing is an essential need in human life. In traditional societies, it simply meant shelter and was emphatically efficient, compatible to the surrounding environment and socially fitting. In designing of sustainable housing, there is a need to address tenants' desires, that reflect their lifestyles and cultures. The incorporation or integration of these dimensions into housing design could lead to a lower overall cost of the product, i.e. maintenance and running cost, renovation and alteration expenses, and enhances sustainability. The design concepts that help to establish a link between the Saudi Muslim culture and sustainable residential housing for mid and low-income earners should include the integration of various elements in building designs, such as relativity to a mosque (Masjid), privacy, environmental sustainability, segregation of men and women in the internal and external environments, and the effective use of light.

The concluding outcome from this paper is shown in the linkage between the Saudi conservative Islamic culture and sustainable design that meets the cultural needs of low and mid-income earners in Saudi Arabia. The link between design elements and cultural aspects showed high level of connectivity between segregation, privacy, environment and relativity to a Masjid, entrances and windows, and courtyards. Other high, mid and low linkage relations were presented in section 4 of this paper. The strongest design element linked to the Saudi conservative Islamic culture was the courtyard.

This paper has clearly shown the link between the conservative Islamic culture of Saudi Arabia and sustainable design of low-rise detached houses, especially by incorporating courtyard design. This paper recommends that further research and studies are done to utilize the ideas and concepts in this paper and implement them in high-rise houses. Further studies might also include how to revolutionize the traditional concepts used in this paper such as the Mashrabiyas and modernize them to be implemented into the design of a Saudi house.

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Appendix G: Third Publication (CIB WBC 2013 Conference)

Integration of Saudi Arabia's Conservative Islamic Culture in Sustainable Housing Design

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Abstract

The cities of Saudi Arabia have perhaps the largest growth rates of cities in the Middle East, such that it has become a cause in shortage of housing for mid and low-income families, as is the case in other developing countries. Even when housing is found, it is not sustainable nor is it providing the cultural needs of those families. The aim of this paper is to integrate the unique conservative Islamic Saudi culture into the design of sustainable housing. This paper is part of a preliminary study of an on-going PhD thesis, which utilises a semi-structured interview of a panel of nine experts in collecting the data. The interviews consisted of ten questions ranging from general questions such as stating their expertise and work position to more specific question such as listing the critical success factors and/or barriers for applying sustainability to housing in Saudi Arabia. Since the participants were selected according to their experience, the answers to the interview questions were satisfactory where the generation of the survey questions for the second stage in the PhD thesis took place after analysing the participant's answers to the interview questions. This paper recommends design requirements for accommodating the conservative Islamic Saudi Culture in low cost sustainable houses. Such requirements include achieving privacy through the use of various types of traditional Saudi architectural elements, such as the method of decorative screening of windows, called Mashrabiya, and having an inner courtyard where the house looks inward rather than outward. Other requirements include educating firms on how to design sustainable housing, educating the public on the advantages of sustainable housing and implementing new laws that enforce the utilisation of sustainable methods to housing construction. This paper contributes towards the body of knowledge by proposing initial findings on how to integrate the conservative Islamic culture of Saudi Arabia into the design of a sustainable house specifically for mid and low-income families. This contribution can be implemented on developing countries in the region that are faced with housing shortage for mid and low-income families.

Key Words: Islamic culture of Saudi Arabia, housing for mid and low-income Families, Sustainable Housing, Semi-Structured Interview, Saudi architectural elements.

1. Introduction

Since the development of the concept of sustainability, nations worldwide have adopted the concept of sustainability and evolved it dramatically since it's conception in 1987 by the U.N. World Commission on Environment and Development (UNWCED). It's well known that the [12]main factor behind the development of sustainability is to make sure that natural resources are not jeopardized for future generations. There are three basic factors that define sustainability: environmental factors, economical factors and social factors; these three factors formulate the sustainability triangle.

Saudi Arabia is a harsh dry climate country where water is a scarce natural resource. Environmental in addition to social factors of Saudi Arabia make the application of sustainability a challenging task that requires the collaboration of all key stakeholders in the country. Several reasons validate the need of applying the concept of sustainability in Saudi Arabia that include, limited natural resources, rapid urbanization rate, growing social awareness, environmental impacts and economical impacts (EL-Batran, 2008; Gamboa, 2008; Garba, 2004; Henderson, 2002b; Karam, 2010; Stensgaard, 2008; Swain, 1998)

Saudi Arabia is experiencing a huge housing crisis (Abdulaal (2011). In Jeddah, for example, the draft of the Jeddah Strategic Plan indicates the severe

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shortage of adequate housing for low and mid-income residents. Abdulaal (2011) goes on to declare that, although there are no sound or scientific statistics to back up this claim, continued growth of unplanned settlements is evidence enough of this increasing shortage of adequate housing for this sector of the public, with nearly one million residents currently living in unplanned areas of Jeddah. “It was estimated that the supply of housing units in Jeddah included 697,000 units in 2007, and there is currently a shortfall of 283,000 homes in Jeddah, including 80,000 in the low income sector. The Jeddah Strategic Plan calls for 151,600 new units to be built to accommodate those people currently living in unplanned settlements, with a further 47,500 units to be built annually to meet the demands of population growth. With regard to future requirements, the strategic plan foresees the need for 953,000 units, and an investment of US$640 billion, over the next 20 years.”(Abdulaal, 2011)

This tremendous growth caused strain in various sectors of the Saudi Arabian economy (Mubarak, 1999). Housing is one of the affected sectors, especially among low and mid-income earners (Gamboa, 2008, p. 4). According to Gamboa (2008), even when one managed to secure housing, it was neither sustainable, nor efficient in the provision of cultural needs of the occupants. And according to Hamed (2003) designing sustainably is no longer a luxury addition to a building, it is now vital to the survival of the present generation and those yet to come.

Compounding the growing housing crisis in Saudi Arabia is the lack of regulations from the government sector concerning the application of sustainable methods. Karam (2010) enforces the lack of regulations by saying that there are no enforceable building codes, nor are there any regulations to follow that integrate the principles of sustainable architecture in the country. He goes on in recognizing the fact that several researchers have debated that one of the most significant and cost-effective ways to foster the prevalent use of sustainable practices is setting a comprehensible set of these codes and standards, specifically with regard to diminishing household energy and water consumption (Karam, 2010). These regulations will need to follow the laws of Islam and incorporate the conservative Islamic culture of Saudi residents.

Saudi Arabia is a conservative Muslim country that follows the laws that are transcribed in the Holy Quran and the Sunnah (sayings and living conducts of the prophet Mohammed). In addition, to understand the economic system of Saudi Arabia, one must comprehend that the economic system is based on the Quran and Sunnah, the accumulated knowledge of Islamic jurisprudence generated by consensus (ijma), analogy (qiyas) and independent interpretation (ijtihad) (Astrom, 2011, p. 76).

As a preliminary study, which was carried out as part of an ongoing PhD research, this paper's focus is how to achieve sustainable housing in Saudi Arabia, with special emphasis or interest on the conservative mosque community. It is based upon this groundwork that this study concentrates in particular on the multifamily detached housing units. It begins with a discussion of challenges that were faced in developing sustainable housing in Saudi Arabia – such as climate, economic and social. It then moves on with the description and discussion of the results from the semi-structured interview, and then finally culminates with some concluding remarks.

2. Challenges Facing Sustainable Housing in Saudi Arabia

High cost of living has discouraged people to implement new ‘expensive’ sustainable housing. The public perception about this ‘new concept’ is expensive, and some of the public are still unaware of this ‘New Concept’. Although the financial benefits are remarkable in the long term, concerns are sometimes voiced about the initial cost of green projects (Cityscape 2010). Munton in Eden (2000) argues that what will determine the success or failure of this international call to arms, will be the local responses that will make it a practical programme (Eden, 2000). Eden goes on and states that local governance in addition to the planning process and the involvement of citizens are critical to the success of the sustainability programme. But to incorporate the local public, they must first of all be educated on sustainability and they should be persuaded on why they should want to participate (Eden, 2000). With the large estimated population in Saudi Arabia, it is no easy task to apply a new concept to a country that has developed from living in tents as recently as the 1930’s. The challenge is not in applying a sustainability scheme to the housing sector, magnanimous as this is, but rather in initially educating the public and government sectors about sustainability, and convincing them that this is the right way to go for the sake of the future as well as strengthening the present.

2.1 Climate Challenges

Harsh dry climate of Saudi Arabia in addition to pollution and global warming raised environmental challenges facing the housing construction industry in the country. The climate in Saudi Arabia is generally harsh, dry desert conditions with extreme temperature differences ranging from -11°C to 51.1°C (Piccolo, 2010). Another environmental challenge that faces Saudi Arabia and other Arab countries is the scarcity of water. In order to react to the increasing demand of water, several Arab countries relied on non-renewable groundwater provisions to amplify their scarce water supply (Swain, 1998). In addition, due to the extremely limited conventional water resources such as fresh surface water and renewable groundwater, alternative sources such as wastewater reclamation and desalination have been adopted since the 1960's (Stensgaard, 2008). In addition to climate challenges and water scarcity, the ecological footprint in Saudi Arabia is approximately 4.5, hectares/capita - almost two times the global average. Compounding this is the fact that Saudi Arabia is among the top 20 countries that are most environmentally challenged (Al Fadl, 2010a).

2.2 Economic Challenges

Saudi Arabia has the largest oil reserve in the world, which has been the main catalyst of the economic growth of Saudi Arabia since the 1930's. This is confirmed by the U.S. Department of State when it states that prosperity from the oil industry has made rapid economic development achievable in the country. (U.S. Department of State, 2011). The near-to-non-existence of mortgage financing is the main factor for the current disequilibrium in the Saudi residential property market.

Although there is a substantial pent-up demand for mid or low-end residential real estate, the actual demand – in other words potential investors able to purchase this type of housing without assistance of a mortgage – is quite limited. Therefore, Saudi property developers are reluctant to even build such projects, hence a further increase in the housing deficit as compared to the needs of the community. Independent economist Saud Jleadan reports that with an annual increase of 150,000 units, the country has a current deficit of two million housing units. Experts of the housing industry such as REFCO (Saudi-based mortgage lender "Real Estate Financing Co.") and Clayton Holdings (U.S. consultancy) have estimated that Saudi homeowners are only 30% of the population – a decrease of more than half of the percentage of the Saudi population, which were homeowners only 20 years ago.

For the world's largest oil exporter, these are striking numbers signifying an alarmingly uneven distribution of wealth and benefits. (Karam, 2010). And what makes matters worse is that there are no regulations or a set of standards that that would safeguard the safety, health and security of tenants (Colvin, 2006, 23). The tendency of Saudi residents to rent over owning originates from the fact that they simply cannot afford to buy a house in the current real-estate market. Houses are being provided by developers at more than SR1 Million ($270,000), but demand is strongest within the SR500,000 – SR750,000 range – evidence resulting from the fact that the average income of Saudi households ranges most generally from 5,200 to 6,000 Saudi Riyals monthly (Savard, et al., 2010).

2.3 Social Challenges

The Saudi culture is defined by the teachings of Islam and is governed by what the Qur'an and the Hadith of the prophet Mohammed (PBUH) state. The culture of Saudi residents is a family oriented culture where all family members are close and the elderly are respected and are considered the wise members of the family. It is not uncommon to find extended families reaching to three or four generations may living in the same house (North & Tripp, 2009). With this multigenerational household in mind, it is evident that the Saudi house would be larger in scale as opposed to those where a single family live in a two bedroom unit or similar.

One of the major social challenges facing sustainable housing in Saudi Arabia is achieving privacy. Privacy is crucial in the design of a Saudi house, and the concept of privacy is perceived from three different areas as stated by Daneshpour (2011), between the neighbours dwelling as well as the street, between the sexes and privacy between individual family members (Daneshpour, 2011). Abu-Gazzeh (1996, p. 271) states, "The concept of privacy has become a subject of growing concern for people, architects, urban designers, landscape architects and social scientists involved in development projects in Saudi Arabia." Al Surf and Susilawati (Al-Surf & Susilawati, 2011) further discuss that unplanned distribution of the residential areas has been the instigating factor resulting in a potentially dangerous mixture of foreign single labour forces living in or nearby previously designated family residential areas. This has led to many serious security issues across the city of Riyadh in addition to the rest of the Kingdom.

The house design should separate private and public life, maintaining their independence. Alhazmi and Nyland (2010, p. 2) point out the importance of gender segregation where it is fundamental to most people's educational, social and political activities. To incorporate this fundamental requirement in housing design, the housing designer should divide the house into three distinct areas: private areas for the inner family members such as the father and the mother, semi-private areas for the whole family, such as the living room. And finally, public guest zones for men and guests. According to El-Shorbagy (2010, p. 15) the traditional Islamic-Arab house layout segregated the house between what is public, semi-public and private areas of the house. He also adds that the design of the house is an inward looking design where the outside walls are generally featureless, which discourage strangers from looking inside.

3. Semi-structured Interview

This research pursues to investigate and interpret the theoretical and practical knowledge of challenges facing sustainable housing in Saudi Arabia. Above and beyond that, this research aims to construct meaning through an interpretation and understanding of the participant's theories, experiences and knowledge. The participant's views are critical to forming the findings of this research and stipulate a specific and locally constructed reality. This paper utilizes a semi-structured interview with experienced professionals as the main research method for its primary data. Careful selection of the panel is necessary to the success of the semi-structured interview. The following criteria were used to correctly identify eligible participants for the interviews:

- Established practitioners/stakeholders considered knowledgeable by the housing construction industry and have extensive working experience in housing construction for Low and Middle-income households in Saudi Arabia.
- Experts directly involved in housing projects (either currently or recently) with a sustainability focus, and
- Experts who are in decision-making roles in organizations or companies associated with sustainable housing projects.
- Knowledge of the local capabilities; and
- Objectivity with respect to sustainable housing policy options and criteria.

3.1 Semi-Structured Interview Background

A total of nine professionals agreed to participate in the semi-structured interview. There were a total of ten questions ranging from broad themes to more specific issues, the first of which was of very general nature, asking of the participant's work experience and relation to the construction industry. Only five questions are discussed in this paper, including one about culture and privacy, due to its significance to the outcomes of this paper. There were a total of ten questions that started from very broad themes, as in discussing the participant's work experience, to very specific issues related to the research. The following were the questions that all nine participants answered to where only the first five questions are discussed in this paper including a question about privacy due to its cultural significance to the findings and outcomes of this paper:

7. What is your interpretation of Sustainable Development, specifically in the housing industry (sustainability definition)?
8. What parameters/factors of sustainability do you account for when dealing with a housing project (the triple bottom line of sustainability)?

9. What are the critical success factors and/or barriers for applying sustainability to housing in Saudi Arabia and how can barriers be managed?

10. In your opinion, does the Saudi Building code discuss or relate to the cultural needs of the Saudi population and their unique cultural characteristics?

11. One of the crucial elements in the design of a Saudi house is it must provide a private environment and out of the sight-range of passing pedestrians. In your opinion how can privacy be achieved in a sustainable way in a Saudi house?

The participants were approached by email invitations that were sent a few times to get their approval to participate, the duration of which took more than one month. The participants ranged from academics to architects to government workers to private contractors, as can be seen in the following Table.

Table 1 Participant Profiles

ID	M/F	Age	Current Position	Education	Job Sector	Years of experience	Worked with sustainable projects	Have Knowledge about the subject	Knows the Saudi Building Code
A-1	M	30-40	Director of Research and Assessment	Master	Private	8	Yes	Yes	Yes
A-2	M	30-40	Architect	Bachelor	Public	12	No	Yes	No
A-3	M	40-50	Architect	Master	Public	12	Yes	Yes	Yes
A-4	M	30-40	Architect (Academia)	PhD	Public	10	No	Yes	No
A-5	F	30-40	Architect	Bachelor	Private	3	No	Yes	Yes
A-6	M	30-40	Architect (Academia)	Master	Public	6	No	Yes	No
A-7	M	30-40	Consultant (Academia)	PhD	Public	12	Yes	Yes	Yes
A-8	M	50-60	Contractor	Bachelor	Private	32	No	Yes	No
A-9	F	50-60	Consultant/Advisor	Bachelor	Private	15	No	Yes	No

3.2 Results and Discussion

Due to the constraints of this paper, not all the results are revealed. Only the important results that were controversial or had a great impact on the researcher's expectations are presented and discussed.

For the first question, the participants had the chance to tell the researcher about their work experience and if they had any contact with sustainable housing projects. The outcome of the question was that three of the nine participants had been in contact with sustainable construction projects, and they were A-1, A-3, and A-7 as illustrated in Table 1, while the remaining six have not been in any contact with any sustainable project.

All the participants had a great deal of knowledge when it came to answering the second question, which was about how would they define sustainable development. Al Surf and Susilawati (Al-Surf & Susilawati, 2011) discussed such awareness by stating although "the sheer new-ness" of the concept is the main barrier, still there is a marked rise in awareness among the public as well as professionals, as we see from the following responses:

- Sustainable housing is any housing, which proves to be environmentally friendly, has low-cost long-term maintenance and is affordable to the consumer.
- A sustainable housing development is a development that is built from local material, which is suitable for the local environment and culture while employing (absorbing) the local weather for its advantage in energy efficiency.
- Sustainable development is mainly the conservation of resources for future generations. It is concerned with the conservation of energy resources for the longest possible period of time.

For the third question, the participants agreed on most of the sustainable design factors, which demonstrated that the participants are aware of the factors that should be incorporated into the design of a Saudi house. The following Table illustrates the response rate in relation to the sustainability factor descending from the highest selected factor to the lowest:

Table 2 Sustainability factors in housing projects

Category/ Theme	Total
Water Management	8
Resources (Materials)	7
Day Light	6
Energy	5
Cost	5
Natural Ventilation	5
Quality	4
Recycling	3

Responses to the fourth question highlighted barriers in applying sustainable methods to housing construction in Saudi Arabia, as revealed in Table 3:

- Lack of public awareness of the positives of sustainable housing.
- Lack of stakeholder interest in applying sustainable housing.
- Shortage in sustainable construction material.
- High cost of sustainable housing and long period of return of investment.
- Low levels of investment in sustainable housing.
- Lack of alternative designs of housing and focusing only on the villa typology.
- Lack of awareness from designing firms of how to design sustainable housing.

Table 3 Barriers to applying sustainability on housing

Critical Success Factors	Worked in Sustainable Projects			Never Worked in Sustainable Projects						Total
	A-1	A-3	A-7	A-2	A-4	A-5	A-6	A-8	A-9	
Lack of stakeholder interest		X	X			X	X	X	X	6
High cost	X	X	X	X	X					5
Lack of public awareness		X		X	X				X	4
Shortage in sustainable construction material			X				X			2

Low levels of investment		**X**				**X**				**2**
Lack of alternative designs	**X**									**1**
Designing firms lack of awareness	**X**									**1**
Total Barriers selected	**3**	**4**	**3**	**2**	**2**	**2**	**2**	**1**	**2**	

The results deducted from Table 3 makes it clear that those having direct contact or real experience with sustainable projects are more inclined to understand the barriers, as these participants are the ones which selected 3 or more of these selections. It is therefore imperative that such persons should be consulted for formulation of a sustainable rating system unique for Saudi Arabia.

On the other hand, the following statements were considered to be critical success factors (CSFs) to applying sustainable methods to housing construction in Saudi Arabia, which can also be found in detail in Table 4:

- All designing firms should be educated on the Saudi building code
- Take advantage of local media to create public awareness of Saudi building code.
- New housing projects must use the Saudi building code
- Renovate Old housing projects to reach the minimum level of the Saudi building code
- The Saudi building code should address and solve local environmental problems

Table 4 Comparison between participants regarding CSFs

Critical Success Factors	Worked in Sustainable Projects			Never Worked in Sustainable Projects						Total
	A-1	A-3	A-7	A-2	A-4	A-5	A-6	A-8	A-9	
Implementing new laws	**X**	**X**	**X**	**X**	**X**	**X**		**X**	**X**	**8**
Educating firms	**X**	**X**	**X**		**X**	**X**		**X**	**X**	**7**
Educating the public	**X**	**X**	**X**		**X**	**X**		**X**	**X**	**7**
Environmental comfort	**X**	**X**	**X**	**X**	**X**	**X**	**X**			**7**
Grey water treatment			**X**				**X**			**2**
Using solar energy		**X**					**X**			**2**
Rainwater collection	**X**	**X**					**X**			**3**
Total CSF's	**5**	**6**	**5**	**2**	**4**	**4**	**4**	**3**	**3**	

Critical Success Factors	Worked in Sustainable Projects			Never Worked in Sustainable Projects						Total
Selected										

From Table 4 it is evident that participants who worked with sustainable projects have selected five or more critical success factors (CSF's) while the other participants who did not have any interaction with sustainable projects have selected less CSF's, illustrating the fact that exposure to sustainable projects greatly impact their judgement of CSF's and how they apply to sustainability on Saudi housing. One of the noticeable results from this Table is that the utilisation of solar energy is one of the least selected CFS's. This can be due to the high cost of installing solar panels as well as the high maintenance cost of such a system.

In relation to the fifth question, which was asking the participants to discuss the Saudi building code (SBC), it was shocking to see that six of the nine participants did not know that there was even such a building code. But it is not surprising to find out that the three participants who have had some interaction with sustainable projects have knowledge of the SBC as it is illustrated in the Table 1.

In response to this reaction, the first thing is that the Saudi building code was not introduced until 2007, which means that is relatively new in the construction industry. The second reason is that the Saudi Building Code National Committee (SBCNC) did not introduce itself to the construction industry well enough so that all the construction industry was informed of the Saudi Building Code. The following outcomes from the participant's responses should be considered as a guideline for the SBCNC:

- All designing firms should be educated on the Saudi building code
- Take advantage of local media to create public awareness of Saudi building code.

- New housing projects must use the Saudi building code
- Renovate Old housing projects to reach the minimum level of the Saudi building code
- The Saudi building code should address and solve local environmental problems

The question regarding the adaptation of privacy in current and future sustainable Saudi housing design had an agreement across the board, which indicates that all the participants agree on the importance of this aspect, both culturally and religiously. Several methods of achieving privacy have been outlined by some of the panel members, which include:

- Refrain from the design constrictions of fenced villas.
- Employment of Mashrabiya concept
- Provision of clearstory fencing along the room walls instead of typical windows
- Designing a house with an introverted concept (looking inside a court).
- Introduce camouflage and pattern in the house, in addition to the idea of a courtyard.

Overall, the concept of privacy can be achieved in the design process of a sustainable Saudi house, which can serve both the cultural and religious needs of its occupants. Designers should incorporate a minimum level of privacy that can fulfil the occupant's needs and any additions or alterations can be done according to the extent and willing of the homeowner.

4. Concluding Remarks

High cost of living has discouraged people to implement sustainable housing concept. The public perception about this ‘concept’ is expensive, and some of the public are still not aware about this ‘concept’. With the large estimated population in Saudi Arabia, it is no easy task to apply a sustainable housing concept to a country that has developed from living in tents in the 1930’s to having a sustainable scheme applied to the housing sector and convince them that this the right way. The findings from the interview suggest accommodating the conservative Saudi Culture in design requirements for sustainable houses. The following points are also derived from the interview:

- Enlightening architectural and construction firms on sustainable designs
- To implement regulations resulting in enforcement of application of sustainable methods in housing construction.
- Encourage Saudi government to erect affordable sustainable housing units.
- Promotion of green energy to become the main energy source for housing.
- The importance of rainwater collection.
- The value of grey water treatment systems

This discussion of the applicability of sustainable methods on the housing construction industry in Saudi Arabia can be utilised for other developing countries in the region that are faced with similar housing shortage especially for mid and low-income families.

Further research is on-going as part of the researcher’s PhD, and results from the first and second Delphi rounds, which are additional research methods used in the PhD thesis, will be available as they arise along the timeframe of the PhD thesis that will discuss further agreement between participants on the research topic.

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Appendix H: Fourth Publication (SASBE Journal)

The current issue and full text archive of this journal is available at
www.emeraldinsight.com/2046-6099.htm

Saudi Arabia's sustainable housing limitations: the experts' views

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Abstract

Purpose – The purpose of this paper is to attempt to bridge the gap between sustainable housing and the use of smart technologies to improve the level of sustainability in the housing construction in Saudi Arabia, by discussing the barriers and enablers concerned with applying sustainability to housing construction in Saudi Arabia, which utilises smart technologies.

Design/methodology/approach – A Delphi method survey was employed, for which 25 individuals from three key stakeholder groups of the Saudi housing sector participated. They were asked about their degree of agreement (or disagreement) about the various barriers and enablers of applying sustainability to housing construction in Saudi Arabia, which utilises smart technologies. This research paper must be considered as an indicative study of selected experts that do not represent in any way the total population of Saudi Arabia.

Findings – Lack of public awareness has been identified as the most significant barrier in implementing sustainable housing development in Saudi Arabia, which utilises smart technologies. Raising awareness of the public to the benefits of sustainable housing and enlightening key project stakeholders in the design of sustainable housing are both essential in order to overcome the barriers discussed in this paper. In addition, it is important to adopt smart sustainable construction methods, exemplified by but not limited to, appropriate water preservation and wastewater treatment systems that are simultaneously smart and sustainable.

Research limitations/implications – This particular research has dealt with only barriers and enablers in the application of sustainability to housing in Saudi Arabia, which utilises smart technologies. For a more complete understanding, there is a need for further analysis of supplementary factors.

Practical implications – A study such as this, which identifies and prioritises barriers and enablers, could prove useful in guiding or encouraging the relevant ministry in Saudi Arabia to develop policies founded in the implementation of sustainability to the housing sector.

Originality/value – This research is a preliminary investigation into the implementation of sustainable housing development as it relates to Saudi Arabia.

Keywords Saudi housing barriers, Saudi housing construction, Saudi housing enablers, Saudi housing problems, Saudi housing stakeholders, Sustainable Saudi housing

Paper type Research paper

1. Introduction

In traditional societies, housing simply meant shelter, whereas nowadays they have become somewhat of a statement of social status instead (Al Surf *et al.*, 2013). Harmony and balance in any society cannot be obtained unless housing is sustainable (Edwards and Turrent, 2013). For the past three to four decades, the Kingdom of Saudi Arabia has witnessed an explosion of economic development, which has been brought about by the discovery and commercial exploitation of oil in the 1930s. The traditional societies of the Kingdom transformed into lifestyles similar to those in many developed societies due to the rising market demand in the 1970s (Mubarak, 1999; Sidawi, 2008).

Smart and Sustainable Built Environment
Vol. 2 No. 3, 2013
pp. 251-271

2046-6099
DOI 10.1108/SASBE-04-2013-0022

Appendix I: Fifth Publication (20th PRRES Conference)

THE ROLE OF THE SAUDI GOVERNMENT AND THE SAUDI BUILDING CODE IN IMPLEMENTING SUSTAINABLE HOUSING CONSTRUCTION IN SAUDI ARABIA

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Abstract

The housing construction industry in Saudi Arabia has been booming rapidly in the past two decades. This boom has faced multiple downfalls in relation to government regulations and building codes, one of which is the application of sustainable methods to the housing construction. This paper sheds some light on the current role of the Saudi government and the role of the Saudi Building Code (SBC) in the housing construction industry. The methodology utilised in this paper was a Delphi survey that was distributed to twenty-five key stakeholders in the housing construction industry in Saudi Arabia. The results indicate that there is a lack of integration between the Saudi Building Code and the current construction methods used in the current construction industry. Some factors and elements are recommended to be incorporated into the Saudi Building Code and to be adopted as regulations in the Saudi housing construction industry.

Keywords: Saudi Building Code, Saudi Housing Construction, Saudi Sustainable Housing, Saudi Housing Stakeholder, Saudi Housing Regulations.

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Introduction

Housing can be seen as the most vital long-term investment one can make for their family. This is because housing provides security, privacy, and stability for the whole family. Furthermore, the house can be seen as a value of which the family living in that house are categorised upon, and it can also represent a social prestige (Opoku & Abdul-Muhmin, 2012). In traditional societies, housing simply meant shelter, whereas nowadays they have become somewhat of a statement of social stamina instead (Al Surf, Susilawati, and Trigunarsayah (2013). People perceived have land and housing as social resources rather than market commodities.

Economic prosperity and urban development in the Kingdom of Saudi Arabia has rocketed in the past two to three decades. The discovery and commercial exploitation of oil in the 1930s coupled with the rising market demand in the 1970s in the Kingdom of Saudi Arabia, and transformed traditional societies into lifestyles similar to those in many developed societies (Mubarak, 1999; Sidawi, 2008). This transformation resulted in an urban sprawl of all major cities in Saudi Arabia. Saudi Arabia's urbanization level, according to the Central Department of Statistics & Information (2010), is at 82.3% of total population and rate of urbanization is 2.38% annual rate of change. The population estimate in 2013 for Saudi Arabia is 29.20 Million which includes 32.1 precent non-nationals (Ministry of Economy and Planning, 2013b). The 2012 census of the five largest urban areas in Saudi Arabia according to administrative regions is Riyadh 7.310 million; Makkah 7.472 million; Eastern Region 4.414.3 million; Medina 1.911 million (Ministry of Economy and Planning, 2013b).

The first sector in the Kingdom to experience the strain was the housing sector, where almost 11.2 million Saudis are estimated to live in rented accommodation of an estimate of 2.2 million rented accommodation units (Central Department of Statistics & Information, 2010), and a shortage of housing has resulted due to sheer increases in rental prices (Riyadh working on rules for private housing, 2013). According to Hamed (2003), designing sustainably is no longer a luxury addition to a building. It is now vital to the survival of the present generation and those yet to come. Al Surf, et al. (2013) have further discussed the issue of rapid urbanization and have explained that fuelling this exploding urbanization rate is the lack of regulation to control the current and future urbanization rate.

This paper discusses the involvement of the Saudi government and its role for achieving sustainable housing in Saudi Arabia. In order to achieve the outlined outcomes in this paper the data collection methods that will be used is from a Delphi survey that was distributed to twenty-five key stakeholders in the housing construction industry in Saudi Arabia. From the collected data, evidence will be discussed in this paper demonstrating the importance of the application of new sustainable construction methods to the housing industry in Saudi Arabia. It is the objective of this paper to conclude with recommendations to the Saudi government (at the national level), regional municipalities, and the construction industry as to the need of adopting sustainable procedures for construction and illustrate the economic, environmental and social benefits of applying sustainability to the housing construction industry.

Saudi Housing

The period of 1990-2010 has witnessed dramatic growth in urbanization of Saudi Arabia as compared with the other developing countries of the Arabian Gulf. EL-Batran (2008) suggests that this high increase in urbanization levels in the Arab region is caused by “high fertility rates, substantial rural-urban migration, international labour migration and the concentration of economic activity in urban areas”. But it’s not just large urban areas that have witnessed this “urban explosion”. Medium and small-sized towns have also experienced the effects of this urban sprawl. This “urban explosion” is good for the future outcome for the country, but the problem lies in the fact that the infrastructure is not coping with the high speed urbanization level of these towns (EL-Batran, 2008).

The Saudi housing typology and inhabitant behaviours and preferences have greatly changed over the past three decades. Traditionally, Saudi families lived in extended family households, where three to four generations may have lived under one roof. Gardens and high walls surrounded houses in traditional Saudi neighbourhoods for privacy, yet some houses were sharing walls with other neighbours creating a city of attached houses. This has greatly transformed and created further upward pressure on housing demand because young Saudi couples are increasingly choosing to live on their own rather than with the extended family (Opoku & Abdul-Muhmin, 2012).

In developing countries like Saudi Arabia, the experience of a rapid rate and ratio of urbanization and infrastructure expansion, especially with respect to residential buildings is immense. Comparing this immense growth with other countries however, the issue of energy efficiency is not given serious consideration with regard to Saudi building designs (Karam, 2010). Assaf, Bubshaitr, and Al-Muwasheer (2010) elaborate on the causes of housing shortage and state “It has become a challenging task for the government as well as private real estate sector in the kingdom to provide affordable housing to lower and medium income group families in urban areas mainly due to high demand, escalating prices and non-preference to (vertical expansion) apartments”. Ferris-Lay (2011) adds that “Saudi Arabia has the largest shortfall in the Gulf of 400,000 homes followed by 40,000 homes in Bahrain, 20,000 in the UAE and 15,000 in Oman, according to property consultant”. The problem is not in the area of urban growth itself. Rather it lies in the rapid rate of the growth, which is in turn surpassing the ability of institutions, administrations and financial atmosphere to properly handle that growth. (Mandeli, 2008).

The Role of the Saudi Government in Sustainable Housing

In this section of the paper, the role of the Saudi government will be discussed from different perspectives shedding light on the crucial elements in the application and progress of sustainable housing construction in the Kingdom. First, the discussion will begin by concentrating on Saudi key stakeholders, who are they and what is their contribution towards enforcing the application of sustainability to housing construction in the country. Second, the increasing price of land will be discussed, which is one of the greatest obstacles in the way of sustainable housing construction in Saudi. Finally, a proposed solution will be discussed, suggesting the possibility of a private-public partnership scheme to applying sustainability to housing construction in the Kingdom.

The majority of the current demographic are under the age of 30, according to Assaf, et al. (2010), where 70 precent of the population are under 30 years of age, and 45 precent under the age of 15. King Abdullah announced a housing scheme in March 2011 to build 500,000 homes over several years. At a time when social dissatisfaction was prompting uprisings in other Arab countries, his plan was part of a series of official steps to improve social welfare (Dokoupil & Rashad, 2013). But since that decree in 2011, not much has happened and the construction of the housing projects has been very slow. This is mainly due to the lack of land given for the construction of these housing projects. However, in April 2013, King Abdullah bin Abdul-Aziz issued another decree removing an obstacle to a $67 billion program to ease the country's housing shortage. The decree was a boost in the housing construction industry in Saudi Arabia, as it brings with it the promise of opening up thousands of acres of state-owned land for these construction projects to take place. (Dokoupil & Rashad, 2013). The first step now for the government after the decree is to fill the gap between the supply and demand of housing in the Kingdom. The Saudi government must address this gap because the young aged demographic of the Kingdom for many years to come will lay the groundwork for sustainable housing (Assaf, et al., 2010).

One problem in Saudi Arabia is that there is no property tax. Consequently, large vacant land lots are found in inner city suburbs, which stand in the way of the Kingdom's urban development. The price of land in the current Saudi property market has increased by 50 precent in the past few years. Furthermore, "land commonly accounts for 50 percent of the cost of building a home in Saudi Arabia, compared with about a third in Europe" (Fattah, 2013). Ferris-Lay (2011) states "The land costs are themselves are a major deterrent and have pushed up the pricing to levels where developers can't make any money out of developing affordable housing". And even if developers bit the bullet and decide to build their development in the outskirts of the city, then they would have to account for infrastructure costs as well, such as roads, power, sewage, schools, hospitals, etc. This has discouraged developers to build affordable houses in Saudi Arabia, crippling the development of the country. To illustrate how much is needed for an average Saudi resident to be able to afford a decent house, Hasan (2011) states "For a Saudi national to acquire a 20 year mortgage loan with 90% financing at an 8% interest rate for a moderate house worth SAR550,500, the minimum required monthly salary should be SAR9,209 to meet the 45% loan to income criteria needed for approval".

Mathur, Price, and Austin (2008) stated that "Sustainability is an ambitious goal which requires, among other efforts, new kinds of governance and decision-making processes involving a large variety of stakeholders". Stakeholder involvement in urban development projects in any country need to "come together to achieve a common goal based on agreed priorities, polling resources and maximizing comparative advantage" (Mandeli, 2008). Collaboration between all stakeholders is essential in the success of any industry to flourish and be prosperous. But "even if the recent green building codes and other initiatives by the Saudi Energy Efficiency Centre (SEEC) and others may be gaining ground in the county, until developers are either mandated to adopt green standards through tougher laws or the financial benefits of green buildings can be more clearly demonstrated, progress is likely to remain limited" (CA News Network, 2013a).

The following is a list of all stakeholders in the Saudi housing industry:

- Ministry of Housing and Public Works (Public Stakeholder)

- The Real Estate Development Fund
- National banks
- The private sector either with or without loans from Real Estate Development Fund
- Institutions, which provide housing for their employees (such as ARAMCO and SABIC).
- Joint-stock companies with funds from both the government and individuals. (Assaf, et al., 2010)

To solve the problem of land availability for affordable sustainable housing projects there needs to be Public-Private Partnership (PPP) “like those already trialled in Morocco and Turkey, could help resolve the problem. The government is allowing developers to build affordable housing on government land. The developer doesn’t pay for the land in cash, they pay for it by providing a certain amount of government housing” (Ferris-Lay, 2011). The following key elements must be present in any PPP:

- A long-term contract (a ‘PPP Contract’) between a public-sector party and a private sector party;
- For the design, construction, financing, and operation of public infrastructure (the ‘Facility’) by the private-sector party;
- With payments over the life of the PPP Contract to the private-sector party for the use of the Facility, made either by the public-sector party or by the general public as users of the Facility; and
- With the Facility remaining in public-sector ownership, or reverting to public-sector ownership at the end of the PPP Contract. (Yescombe, 2011)

According to Mandeli (2008) the Saudi government has begun privatizing some of its municipality’s roles such as “city cleaning, pest control, outsourcing vehicle supply, recreational facilities and other services”. There is with no doubt a huge advantage for the Saudi government to start establishing partnership contracts with the private sector, but the problem is “the lack of necessary knowledge base for assessing the advantages of public–private partnership has caused the inability of both central and local authorities to develop a clear legal framework, performance dimensions or risk evaluations regarding these opportunities gained from a privatized programme. Moreover, the limited fiscal and legal power of local authorities compounded by a shortage of staff, limits the scope upon which municipal enterprise can develop” (Mandeli, 2008). The Saudi government can have a direct influence in the implementation of sustainable building through the Saudi Building Code. The next section will discuss the international initiatives on incorporating environmentally-conscious principles in the building codes. Then, the role of the Saudi Building Code (SBC) will be reviewed on the implementation of Sustainable Housing concept.

Opportunities of environmentally-conscious building codes

The sole purpose of building codes is to protect the inhabitants from building related risks such as fire, structural collapse and other risks. Additionally, environmental performance assessment of built projects across a range of key criteria is the reason behind developing green rating systems. In the past two to three decades, the focus of governments such as the US, Canada, UK, and Australia are to make the building codes environmentally friendly. Those governments have developed building codes that promote sustainability such as LEED, BREEAM, Green Globes, and Green Star. This global movement towards a more conscious construction environment is still voluntary and the rating systems such as LEED are still a third party in the construction industry. The U.S. Green Building Council states " The advent of green building codes and standards is a direct result of the wide-sweeping impacts of green building rating systems like LEED demonstrating that buildings really can be designed and built to lower operating costs, increase value, and reduce their overall impacts" (U.S. Green Building Council). While green building codes are still voluntary, green building activists and sustainable real-estate stakeholders are pushing governments to mandate these green building codes. To illustrate the importance of mandating green building codes, the U.S. Green Building Council states "in today's greenest buildings, our impact is still net negative. On the road to sustainability, it's not a choice between rating systems or codes. We need both, and more." (U.S. Green Building Council). Figure 1 is adopted from the U.S. Green Building Council's LEED and Green Building Codes Policy Brief where it illustrates the huge negative environmental impact of buildings at the present day and it also shows how far we still have to go for our buildings to achieve zero environmental impact.

Environmental disaster such as hurricanes, earthquakes, floods and fires test any building's structural integrity to the limit. Building codes help improve and maintain a building's structural stability that will withstand any hazards such as fire and structural collapse. Additionally, building codes can serve to reduce the impact of environmental disasters that may occur just like what happened in the US from hurricane Katrina in 2005 and the earthquakes of Christchurch in 2010. According to Rotimia, Masuriera, and Wilkinsonb (2006) "Legislation that applies to routine construction provides for the safe development of infrastructure, capital improvements and land use, ensuring preservation and environmental protection, however there appears to be little provision in several areas of legislation to facilitate reconstruction projects." Post disaster restorations can utilise the shortcomings of a building's pre-disaster structural conditions to improve it for any future disasters that may occur in the area. This must be the case in area where environmental disasters occur frequently. Amaratunga and Haigh (2011) state "Post disaster period provides a window of opportunity to address many of the vulnerabilities usually encountered in a community's built environment" and post disaster creates a fresh start to rebuild non-vulnerable communities where disaster risks can be addressed effectively. "Furthermore, the experience gained during the disaster typically generates new knowledge, which brings various stakeholders together around a shared awareness of the nature of risk. The mistakes of previous development policies and strategies are exposed and can be addressed." (Amaratunga & Haigh, 2011). Lee (2013) states "While the restoration of key urban infrastructure after collapse is vital to making a place accessible and habitable again, the research has found that building communities is equally, if not more, important than the physical reconstruction of a place." In addition, "Disaster can serve as a catalyst for renewing community spirit and resilience against future disasters, and, in many cases, creates an even stronger sense of community than before" (Lee, 2013).

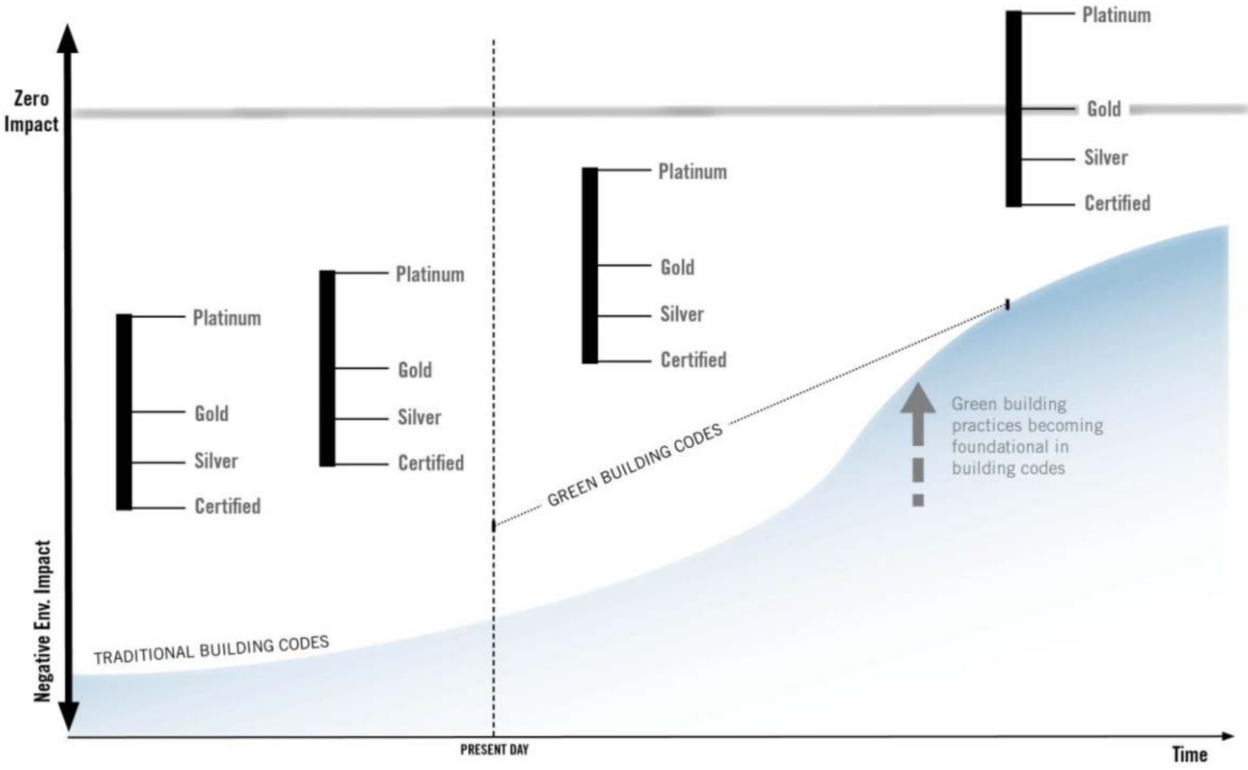

Figure 1 LEED, Codes and Green Building Codes (U.S. Green Building Council)

The Role of the Saudi building code (SBC) and Sustainable Housing

Inception of the Saudi Building Code (SBC) started in 2000 when a Royal Decree formulated the Saudi Building Code National Committee (SBCNC) and the first version of the SBC was available for the public in 2007. The following paragraphs describe what the SBC is and what its role is according to the Saudi Building Code National Committee:

> *"The Saudi Building Code (SBC) is a set of legal, administrative and technical regulations and requirements that specify the minimum standards of construction for building in order to ensure public safety and health. A Royal Decree dated 11th June 2000 order the formation of a national committee composed of representatives of Saudi universities and governmental and private sectors. In*

September 2001, the Council of Ministers approved the general plan of the National Committee to develop a national building code for the Kingdom of Saudi Arabia.

To choose a base code for the Saudi Building Code, a number of Codes have been studied. The National Committee has been acquainted with the results of the national researches and the international codes from the U.S.A., Canada and Australia, also, the European Code, and Arab Codes. It has also sought the opinions of specialists in relevant Saudi universities, governmental and private sectors through holding a questionnaire, a symposium and specialized workshops, in the light of which, (ICC) has been chosen to be a base code for the Saudi Building Code.

The International Code Council (ICC) grants permission to the Saudi Building Code National Committee (SBCNC) to include all or any portion of material from the ICC codes, and standards in the SBC and ICC is not responsible or liable in any way to SBCNC or to any other party or entity for any modifications or changes that SBCNC makes to such documents.

Toward expanding the participation of all the specialists in the building and construction industry in the Kingdom through the governmental and private sectors, the universities and research centers, the National Committee took its own decisions related to code content by holding specialized meetings, symposiums and workshops and by the help of experts from inside and outside of Saudi Arabia.

The technical committees and sub-committees started their work in April 2003 to develop the Saudi Building Code that adapts the base code with the social and cultural environment, the natural and climatic conditions, types of soil and properties of materials in the Kingdom." (Saudi Building Code National Committee, 2007)

The Ministry of Municipal and Rural Affairs (MOMRA) is the main government body under which the Saudi Building Code National Committee operates. Some of the MOMRA's tasks and responsibilities are: "classification of contractors, management of the construction and building sector database, management of the Mina and the Holy Sites Development Project, and the building and construction laboratories. During the Eighth Plan, other responsibilities were added, such as: managing and implementing the Building Code, applying the real-estate registration system in coordination with the Ministry of Justice, and issuing municipal licenses for commercial, industrial, artisanal and vocational activities" (Ministry of Economy and Planning, 2013a).

Since March of 2007 the concept of sustainable buildings in Saudi Arabia was not a reality and immature practicing was done at that time and prior to it. But after the formulation of the Saudi Green Building Council in March 2007, the Saudi Building Code was one of the main objectives of this council. "Saudi Green building Council is promoting and facilitating the green building practice in Saudi Arabia. This includes raising public awareness, provide training and education, helping the construction industry convert to the green building requirements, encourage building materials manufactures and suppliers to produce and supply environmentally responsible products, promote green labeling, adapt, develop and operate local green building rating system that meet the local environmental requirements while considering the international experience" (CA News Network, 2013b).

This paper discusses the challenges facing the application of sustainability on housing in Saudi Arabia by focusing on the role of the Saudi government and the

Saudi building code (SBC) in implementing sustainable housing construction in Saudi Arabia. It commences with a description of the method of research employed, the Delphi method, which in this case involved a survey distributed to twenty-five participants from three key stakeholder groups of the housing sector of Saudi Arabia. Following the initial layout of the data from this research method that has been engaged, it progresses into a discussion on the role of the Saudi government and the Saudi building code (SBC) in implementing sustainable housing construction in Saudi Arabia.

Research Method

For clarification reasons, this paper and the results outlined are the outcome of a Delphi round distributed to twenty-five participants of three key stakeholders groups of or related to the Saudi housing sector. Two questions will be discussed here which were part of the Delphi round:

> *"It is well known that the initial payment for a sustainable house is higher than a normal house. How can Low and Middle-Income families afford to pay for sustainable houses, and can the government intervene in making it more affordable (i.e. Incentives, Grants)?"*
>
> *"In your opinion, does the Saudi Building code discuss or relate to the cultural needs of the Saudi population and their unique cultural characteristics?"*

For the Delphi round, twenty-five participants of three key stakeholders groups of or related to the Saudi housing sector were selected as panel members. They were carefully selected based on their expertise and experiences. Several factors were considered for the selection of the panel members, whereas they should be:

- Established practitioners/stakeholders who are considered knowledgeable by the housing construction sector and have extensive working experience in housing construction projects for Low and Middle-income households in Saudi Arabia.
- Experts who have been directly involved in housing projects (either currently or recently) with a sustainability focus.
- Experts who are in decision-making roles in an organization or company associated with sustainable housing projects.
- They should be knowledgeable of the local possibilities and restrictions as concerns implementation of sustainability to housing.
- They should be unbiased in respect to sustainable housing policy options and criteria, enabling viable solutions when faced with barriers.

This methodology was first used by the RAND (Research and Development) Corporation for the American military in 1944 for technology forecasting studies (Hanafin, 2004). The Delphi method can be defined as "a research approach used to gain consensus through a series of rounds of questionnaire surveys, usually two or three, where information and results are fed back to panel members between each round." (Hanafin, 2004). Linstone and Turoff (2011) also defined the Delphi as "A technique to apply expert input in a systematic manner using a series of questionnaires with controlled opinion feedback". McCoy, Thabet, and Badinelli (2009) state "The Delphi Method acquires the opinions of experts through a series of surveys. The responses to each survey are returned to the researcher who summarizes them and reports to each panel member all of the opinions expressed by the panel. However, these reports are anonymous so that the pitfalls of ego, domineering personalities and the "bandwagon or halo effect" in developing consensus are avoided."

To justify why the Delphi method was selected in the first place, Franklin and Hart (2007) present the answer of why are researchers interested in collecting the opinions and judgments of a panel of experts due to the following points:

12. To document and evaluate those opinions and judgments
13. The apprehension of the collective knowledge held by that panel of experts that often cannot be expressed and explored.
14. The emergence of new ideas related to the topic may be evoked (Franklin & Hart, 2007)

Additionally, Delphi is desirable in that it does not require the experts to meet physically, which could be impractical for an internationally diverse panel of experts. Furthermore, the Delphi study is flexible in its design, and amenable to follow-up interviews. This permits the collection of richer data leading to a deeper understanding of the fundamental research questions. The objective of the Delphi method is to ''reduce the negative effects of group interactions'' and to obtain the most reliable consensus of opinion of a group of experts. The Delphi method can be classified by four characteristics, which are anonymity, iteration, controlled feedback, and the statistical aggregation of group response." (Rowea & Wrightb, 1999). Gordon (1994) States "Because of the small number of respondents, the Delphi method does not (and was not intended to) produce statistically significant results; in other words, the results provided by any panel do not predict the response of a larger population or even a different Delphi panel. They represent the synthesis of opinion of the particular group, no more, no less.” For this reason, this research paper, which was conducted with the twenty-five panelists, must be considered as an indicative study of selected experts that do not represent in any way the total population of Saudi Arabia. Their opinions and answers to the survey may be used to formulate a set of rules and regulations that can then be introduced to the public for their input as to whether or not those sets of rules and regulations can or should be applied.

Delphi Round Analysis

The analysis of the Delphi round utilises the Mean, Median, Mode, Standard Deviation, and Varience. “The mean is simply the arithmetic average of a distribution of scores the median is the score in the distribution that marks the 50th percentile. That is, 50% of the scores in the distribution fall above the median and 50% fall below it. The mode simply indicates which score in the distribution occurs most often, or has the highest frequency. The Standard Deviation is the average deviation between the individual scores in the distribution and the mean for the distribution. The Variance is the sum of the squared deviations divided by the number of cases in the population, or by the number of cases minus one in the sample.” (Urdan, 2012)

The focus of this paper, which is based on the first round of the Delphi, is centred on the role of the Saudi government and the Saudi building code (SBC) in implementing sustainable housing construction in Saudi Arabia. As a requirement for this round to be classified as a Delphi round, the participants will remain anonymous here, with only a description of their roles as stakeholders and their years of experience being revealed for the sake of authenticating and validating this study. There were a total of three academics, eight government officers and fourteen from the private sector. The experts that were selected for this Delphi round were all knowledgeable on sustainability issues, but differed as to whether or not they had actually participated in or worked on a sustainable project.

The participants were given a range of choices to choose from that used a six-category Likert scale. The categories are illustrated in Table 1. The reason for choosing six choices for the participants to select from is because such diversity is needed in this type of research and the researcher has chosen to limit input from the participants to either agreeing or not agreeing upon a certain question. The level of agreement can differ from strongly disagree to strongly agree, but the end result is that the participant either agrees or does not agree. The reason for this influence upon the participants is due to the cultural background of the participants, where an undefined choice can cause the results to be unworthy; hence the choices were either levels of agreement or disagreement only. Stening and Everett (1984) state "Individuals have different tendencies to use certain types of responses: extreme, neutral, agree, or disagree". The reason of selecting this type of scale is also reinforced in the statement by Wong, Peng, Shi, and Mao (2011) that participants "may be more reluctant to express their opinions strongly and that this may be reinforced if the odd number response format with a mid-point option of "no opinion" or "neither agree nor disagree" is provided. This may undermine the quality of survey data because less variances or even inaccurate information will be collected."

Table 1 Rating of Answers

Rating Description	Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
Rating Value	1	2	3	4	5	6

Analysis on the Role of the Saudi Government

The following question was asked from the participants in the first Delphi Round regarding the role of the Saudi Government:

The Saudi government through several ministries and local municipalities has great influence on the housing construction in Saudi Arabia. This section will get the panel's perception on the role of the Saudi government in the housing construction industry in Saudi Arabia. Please select the appropriate level of agreement to the following questions:

15. How extensive does the Saudi government intervene in the design and construction of houses in Saudi Arabia?
16. How would "change" in the ideas of the Saudi population regarding the application of sustainable methods on housing, be acknowledged by the Saudi government and other official bodies in Saudi?
17. The Saudi Building code discuss or relate to the cultural needs of the Saudi population and their unique cultural characteristics
18. Design firms stick to and follow the Saudi Building code

Table 2 demonstrates the responses from the panel members of the Delphi round to the questions concerning the role of the Saudi government in the housing construction industry in Saudi Arabia. The Table represents the total ratings from all the participating stakeholders. The Table has been organized according to the mean, mode and median, that was used to provide the rating of each indicator while the standard deviation was used to examine the uniformity/convergence of each indicator. For this round 1, the indicators were categorised based upon the mean cut-off score. The indicator was rated high if the mean score was equal to or higher than 5. The indicator was rated medium if the mean was equal to 4 and less than 5, while the indicator was rated low if the mean was below 4.

Table 2 Responses from the panel members of the Delphi round to the Role of the Saudi Government

Question	Median	Mean	Mode	Standard Deviation	Variance	Min	Max	Rank
1	3	3.625	2	1.438976085	2.070652174	2	6	Low
2	4	3.416666667	4	1.31601066	1.731884058	1	6	
3	3	3.375	3	1.244553351	1.548913043	1	6	
4	3	3.333333333	3	1.403928236	1.971014493	1	6	

Analysis on the Role of the Saudi Building Code (SBC)

The following question was asked from the participants in the first Delphi Round regarding the role of the Saudi Building Code (SBC):

The Saudi Building Code is a set of rules and regulations that designers, contractors and all construction stakeholders should/must refer to and it was approved and published in 2007. Please select the appropriate level of agreement to the following elements:

19. All designing firms should have a good understanding of the Saudi building code
20. New housing projects must use the Saudi building code at least to the minimum standards
21. I have heard of the Saudi Building Code
22. Increase public awareness of the Saudi building code, e.g. through local media.
23. Existing houses need to be renovated to reach the minimum level required by the Saudi building code
24. Saudi Architectural designing firms don't use the Saudi Building Code
25. I have extensive knowledge of the Saudi Building Code
26. I use the Saudi Building Code constantly
27. The Saudi Public has knowledge about the Saudi Building Code
28. The Saudi Building Code is new to me and I have not used it or had any experience with it
29. This is the first time I have heard of the Saudi Building Code

The participants were again given the chance to rank their answers according to the ranks in Table 1 above. Table 3 below demonstrates the responses from the panel members of the Delphi round to the questions concerning the role of the Saudi Building Code (SBC) in the housing construction industry in Saudi Arabia. The Table represents the total ratings from all the participating stakeholders. The Table has been organized according to the mean, mode and median, that was used to provide the rating of each indicator while the standard deviation was used to examine the uniformity/convergence of each indicator.

Table 3 Responses from the panel members of the Delphi round to the Role of the Saudi Building Code

Question	Median	Mean	Mode	Standard Deviation	Variance	Min	Max	Rank
1	6	5.44	6	0.768114575	0.59	3	6	High
2	5	5.08	5	1.037625494	1.076666667	1	6	
3	5	4.96	6	1.240967365	1.54	2	6	Medium
4	5	4.92	5	1.077032961	1.16	2	6	
5	5	4.36	5	1.380821012	1.906666667	1	6	
6	4	3.68	4	1.107549848	1.226666667	1	6	Low
7	3	3.32	2	1.375984496	1.893333333	1	6	
8	3	2.76	2	1.331665624	1.773333333	1	5	
9	2	2.52	2	1.357694124	1.843333333	1	6	
10	2	2.48	2	1.446835628	2.093333333	1	6	
11	1	1.88	1	1.30128142	1.693333333	1	5	

Discussion

In analysing the role of the Saudi government in the housing construction industry in Saudi Arabia, overall, as can be seen in Table 2, all the elements were ranked to be low because the mean was lower than 4. The response from the participants was not surprising. For the first question that was asked under the involvement of the Saudi government section, which was “how extensive does the Saudi government intervenes in the design and construction of houses in Saudi Arabia”, it had the largest variance when compared to the other elements. It also had the largest standard deviation compared to the other elements in Table 2. To illustrate the level of disagreement Figure 3 is a histogram that shows a bell curve peaking towards disagreement, which happens to be on the left portion of the graph. 52 precent of participants disagreed that the Saudi government intervenes in the design and construction of houses in Saudi Arabia. This can be seen as a major setback in the progress of the development and application of sustainable housing construction. Because as Mathur, et al. (2008) stated, “Sustainability is an ambitious goal which requires, among other efforts, new kinds of governance and decision-making processes involving a large variety of stakeholders”.

Question three in Table 2, which was “the Saudi Building code discuss or relate to the cultural needs of the Saudi population and their unique cultural characteristics” had the lowest standard deviation and variance when compared to the other elements. But in totality, all the elements were ranked to be low which can lead to one conclusion; there is lack of involvement or intervening from the Saudi government when it comes to the role of the Saudi government in the housing construction industry in Saudi Arabia especially in sustainable housing construction. But to overcome this level of disagreement, this paper encourages that all Saudi housing construction stakeholders be involved for the development of all projects.

This can have a better outcome when all come together to achieve a common goal which is to achieve sustainability. And since Constructing green and sustainable buildings is 2 to 13 precent more costly than constructing traditional buildings (CA News Network, 2013b), the Saudi government's role can be to minimize what it can to the overall cost of constructing green and sustainable buildings.

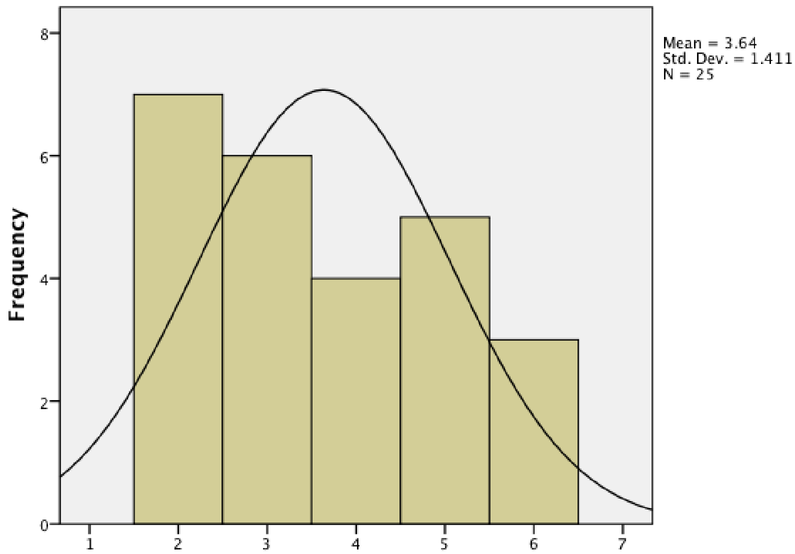

Figure 2 Levels of agreement/disagreement on how extensive does the Saudi government intervenes in the design and construction of houses in Saudi Arabia.

In analysing the role of the Saudi Building Code (SBC) in the housing construction industry in Saudi Arabia, there is a difference in responses to different elements as can be seen Table 3. Elements 1 and 2 were ranked high. Elements 3, 4, and 5 were ranked medium. And elements 6, 7, 8, 9, 10, and 11 were ranked low. The highest ranked element was "all designing firms should have a good understanding of the Saudi building code" with a mean value of 5.44 and standard deviation of less than 1. The level of agreement on this element is very encouraging and should be addressed to the stakeholders in the Saudi government to make the

SBC mandatory and be applied to all current and future housing construction projects. This paper recommends that the Ministry of Municipalities and Rural Affairs (MOMRA) as the governing body of the application of the Saudi Building Code (SBC) in collaboration with the Ministry of Housing and Public Works (MOHPW) should mandate the use of the SBC in all construction project especially housing projects. This is because housing construction projects are on the rise both in price and in demand. And according to Naffee (2013) “there is an increase in demand and a lack of supply of housing units due to the high prices of building material in the summer. There are also fears that the prices of units will increase further”.

The lowest ranked element is “This is the first time I have heard of the Saudi Building Code” with a mean value of 1.88. The level of disagreement on this question means that there is a large gap between those who have heard about the SBC and those who don’t know of it. Figure 4 demonstrates the high peak of disagreement, which means that the majority of participants have heard of the SBC but vary in the level of involvement by using the SBC as illustrated in Figure 5. This can mean one thing; the sheer-newness of the SBC can have a great influence on the level of involvement of key stakeholders. And since it’s not mandatory to utilise the SBC yet, then this level of involvement will not change to the desired level of all stakeholders being involved and applying the SBC. Even though, the Kingdom of Saudi Arabia is trying to build smart and sustainable buildings and “has announced its intention to spend SR 150 billion (US$ 39.9 billion) over a period of eight years beginning 2010 for the construction of “smart buildings” across the Kingdom” (Ventures Middle East, 2011), the novelty of the SBC is yet to be applied on all construction projects, especially housing, where it can be seen and assessed in the near future.

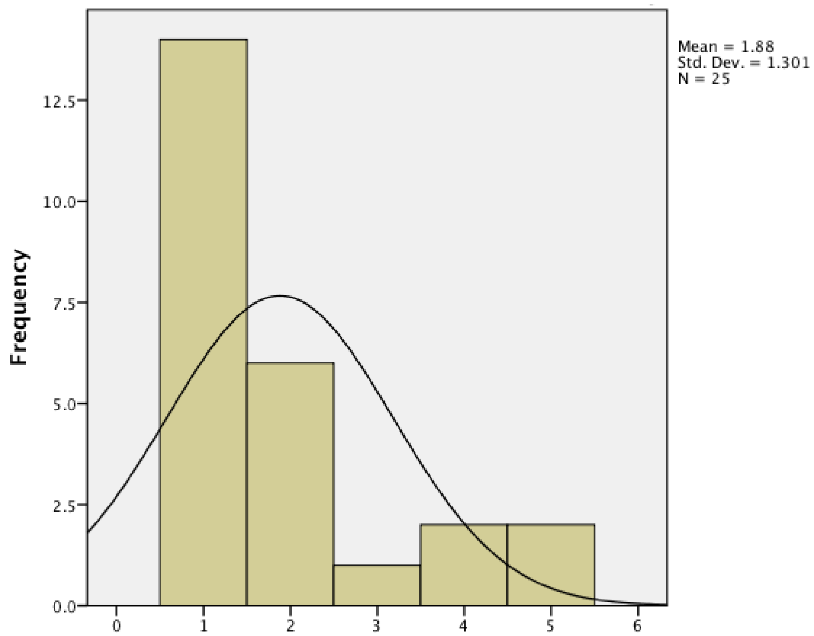

Figure 3 Levels of agreement/disagreement on "This is the first time I have heard of the Saudi Building Code".

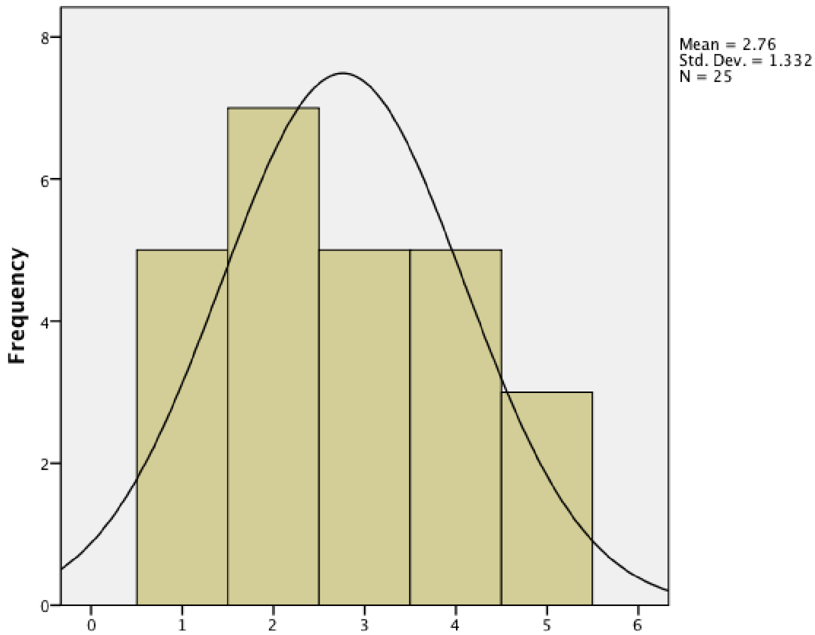

Figure 4 Levels of agreement/disagreement on "I use the Saudi Building Code constantly".

Conclusion

This paper has shown the results from the role of the Saudi government section as well the role of the SBC section of the Delphi method round. The Delphi round was conducted with twenty-five panelists and must be considered as an indicative study of selected experts that do not represent in any way the total population of Saudi Arabia. Their opinions and answers to the survey may be used to formulate a set of rules and regulations that can then be introduced to the public for their input into whether or not those sets of rules and regulations can be applied. All the elements asked in the role of the Saudi government section were ranked to be low because the mean was lower than 4. In totality, all the elements were ranked to be low which can lead to one conclusion; there is lack of involvement or intervening from the Saudi government in the housing construction industry in especially in sustainable housing construction. This paper encourages that all Saudi housing construction stakeholders be involved for the development of all projects. This can have a better outcome when all come together to achieve a common goal which is to achieve sustainability. And since Constructing green and sustainable buildings is 2 to 13 precent more costly than constructing traditional buildings (CA News Network, 2013b), the Saudi government's role can be to minimize what it can to the overall cost of constructing green and sustainable buildings.

In analysing the role of the Saudi Building Code (SBC) in the housing construction industry in Saudi Arabia, there is a difference in responses to different elements. Elements 1 and 2 were ranked high. Elements 3, 4, and 5 were ranked medium. And elements 6, 7, 8, 9, 10, and 11 were ranked low. The highest ranked element was regarding all designing firms should have a good understanding of the Saudi building code with a mean value of 5.44 and standard deviation of less than 1. The lowest ranked element is “This is the first time I have heard of the Saudi Building Code” with a mean value of 1.88. The level of disagreement on this question means that there is a large gap between who have heard about the SBC and who do not know it or have even heard of it. Figure 4 demonstrated the high peak of disagreement, which means that the majority of participants have heard of the SBC but vary in the level of involvement by using the SBC as illustrated in Figure 5. The sheer-newness of the SBC can have a great influence on the level of involvement of key stakeholders. And since it’s not mandatory to utilise the SBC yet, then this level of involvement will not change to the desired level of all stakeholders being involved and applying the SBC.

In conclusion, both the role of the Saudi government and the Saudi Building Code (SBC) must be assimilated in housing construction to reach the desired outcome, which is to achieve sustainable housing construction in Saudi Arabia. The application of the SBC must be mandatory in both current and future housing construction projects. Even though, the Kingdom of Saudi Arabia is trying to build smart and sustainable buildings the novelty of the SBC is yet to be applied on all construction project especially housing where it can be seen and assessed in the near future. And as discussed earlier, the application and mandating of new improved building codes that address various risks such as environmental hazards is vital to the success of building new communities.

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Appendix J: Sixth Publication (AsRES 2014)

Case study analysis for the Development and Implementation of Sustainable Housing in the Kingdom of Saudi Arabia

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Abstract

Rapid urbanization in developing countries is putting stress on current infrastructure, which is resulting in the rapid consumption of natural resources to cope with the increasing demand of the population. Saudi Arabia is one of the developing countries facing rapid urbanization where its infrastructure is facing a huge demand by the increasing urbanization levels of its major cities. Developing sustainable housing in Saudi Arabia is a must for the preservation of resources for future generations of the region and of the world. In the coming years, several resources (such as fossil fuels and natural water) will be facing shortage if not managed properly. Providing electricity for housing in Saudi Arabia is one of the biggest challenges facing the country, where it is estimated that by 2050 energy demand in the Kingdom will be approximately 120 GW, and to meet this growing demand, 8 million barrels of oil per day will be required. However, implementation of Sustainable Housing in Saudi is still problematic to reach the desired goals of various key Saudi stakeholders. This paper analyses three case studies that have adopted sustainable construction methods and compares them to traditional non-sustainable houses. The outcome suggests that there is a viable chance for development of sustainable housing in the region if supported by the government with less red tape to deal with. This paper recommends that the Saudi governments should mandate new laws to reduce the overall consumption of energy and water to reduce the overall consumption of natural resources to secure the future generation's demand of natural resources.

Keywords: Saudi Housing Construction, Saudi Sustainable Housing, Saudi Housing Stakeholder, Saudi Renewable Energy, Saudi Housing Case Study.

1. Introduction

Asia and the Pacific region in 2010 had an urbanization level of 43 per cent which was "the second lowest urban proportion of a region in the world; however, in the last two decades the Asia-Pacific urban proportion has risen by 29%, more than any other region"(United Nations, 2011). Of all the Asian and Pacific sub-regions, South and South-West Asia had the fastest urban population growth rate at an average of 2.4% per year during 2005-2010 (United Nations, 2011). Saudi Arabia is one of the countries that is located in the South-West Asia and is faced with a high percentage of urbanization. According to (Al Surf, Susilawati, & Trigunarsyah,

2013) Saudi Arabia's urbanization level increased strikingly from 10% to 75% in a period of 42 years. And according to (Bonetti, 2009) "The largest and fastest growing building markets are today found in the developing world". Several factors influence on the rate of urbanization which include:

- Internal migration from rural to urban
- Natural disasters
- Access to better opportunities and services
- Political conflicts. (United Nations ESCAP, 2013)

With this high number of population moving into large cities, the responsibility of governments to provide adequate and sustainable infrastructure and services are ever more important. Some of the infrastructure in developing countries is not coping with the high number of occupants such as electricity and water. The role of sustainability and the utilization of sustainable construction methods are undoubtedly important for the preservation of natural resources. In the coming years, several resources, such as fossil fuels and natural water, will be facing shortage if not managed properly. More people moving into large cities means more buildings will be built, which also means more stress on infrastructure, which can only lead to more consumption of natural resources that will produce more greenhouse gas emissions. According to the (United Nations Environment Programme, 2009) "Buildings are responsible for more than 40 percent of global energy use and one third of global greenhouse gas emissions, both in developed and developing countries".

This paper discusses the importance of constructing sustainable buildings where the focus will be on sustainable housing. It analyses three case studies that have adopted sustainable construction methods in their design and are compared to traditional non-sustainable houses. The comparison highlights the effectiveness of reducing energy consumption, water consumption, effective use of sustainable building materials and incorporating the culture into the design to achieve better living conditions for the inhabitants.

2. Natural Resource Crisis in Developing Countries

The world population is consuming natural resources much faster than the planet can replenish. Developing countries are facing numerous challenges aside from depleting natural resources. The uprising in the Middle East region, which started in 2010 by the unrest in Tunisia followed by Libya, Syria and Egypt, is causing even more chaos than what previously existed. The Middle East and North Africa region (MENA) is considered to be one of the driest regions in the world where natural renewable water sources account for 1.2 per cent of the world's renewable water resources. Two main reasons are adding pressure on water sources in the region, rapid population growth and high urbanization. Some countries in the region, such as the Kingdom of Saudi Arabia, can afford desalination plants; others are forced to drawing on aquifers faster than they can be naturally replenished, or overdraw on non-renewable water resources (Andersen, 2014).

Within a period of 40 to 200 years, non-renewable natural resources, such as oil, natural gas and coal, will be consumed if not managed in a sustainable way to last for future generations (Ting, Mohammed, & Wai, 2011). Availability of natural resources in any country can mean economic prosperity and a better life style of its residents. Oil, for example, has made the Kingdom of Saudi Arabia a rich country and it has dramatically transformed from a tribal desert country into one of the world's largest oil producing and exporting countries. The world population is aware of the current climate change and global warming is no longer a myth. On the contrary, it is a reality, where MENA opinion polls show that 80 per cent of the population consider this matter to be very serious (Andersen, 2014).

Preservation and managed use of natural resources for the sake of future generations is one main concept that is common among all the definitions available in the literature on Sustainability. (Miranda & Marulanda, 2001) argue that a key point for sustainable construction is "the consideration to minimize energy wastage, taking rational advantage of the natural conditions without altering them and allowing other living forms to live and be preserved". Hence, preservation of natural resources can be achieved through the application and adaptation of sustainable construction methods. Developing countries are still under development and that gives them the advantage of applying the concepts and applications of sustainability while projects are still under development.

Saudi Arabia is one of the developing countries in Asia, and applying sustainable applications and systems to the built environment at this stage can help preserve the country's natural resources for future generations. (Husain & Khalil, 2013) point out the environmental challenges facing the Kingdom of Saudi Arabia:

- Air quality deterioration in urban areas
- High energy demand and consumption due to regional population growth and economic development
- Concerns about safe drinking water supplies due to a scarcity of fresh water
- Industrial pollution
- Waste management
- Pollution in coastal areas; and subsequent stress on marine ecosystems

Sustainable Development in Saudi Arabia is considerably new and the concept was first formalized through King Abdullah's initiative in 2010 where the only sustainable project at that time was King Abdullah University of Science and Technology (KAUST). In 2013 the number of sustainable and green projects has risen to reach 140 projects where 40 of them are located in the Kingdom's capital (Rasooldeen, 2013). In the fourth Saudi Green Building Forum (SGBF), the Secretary General of the SGBF, Faisal Al-Fadl, signed a Memorandum of Understanding with UN-Habitat's Regional Office for Arab States' Director, Dr. Mostafa Madbouly, launching the first Arab Network for Green Buildings. "The agreement aims at enriching professional architecture and the science of green buildings, through creating a forum for knowledge and experience exchange to contribute to sustainable urban development. It also aims to conserve architectural heritage and natural resources while limiting the detrimental effects of urbanization on the environment. This will further add to the experience of professionals in Saudi Arabia, Egypt and other Arab countries, in both the public and private sectors" (UN-Habitat, 2013)

The literature presents numerous discussions on the issue of energy and conserving the consumption of energy around the world and in developing countries in particular (Bhattacharyya, 2009; Erdmenger et al., 2009; Fenerty-McKibbon & Khare, 2005; KAUST Industry Collaboration Program, 2013; Khare, 2005; Kikuchi, Bristow, & Kennedy, 2009; Liao, Yao, & Chin, 2008; Say & Yucel, 2006; Schumacher, 1985; Ting, et al., 2011). The bottom line is "To become a sustainable society, the world must consume less energy" (Ting, et al., 2011). Energy is not only essential to cater to human needs and allow them to maintain their activities including social, cultural, technological, medical, and economic development, but also it is a matter of protection of the environment and prevention of pollution.

"Energy conservation is the need of the hour" (Ting, et al., 2011), this is the bottom line that needs to be clear and understood by all energy consumers. New technologies and techniques have been developed to help reduce the daily consumption of energy and water. Achieving sustainability rating in a building using any of the world known rating systems such as LEED requires a building to comply with energy and water conservation requirements. For example, the minimum LEED requirement to get a building certified in terms of energy efficiency is a 10 per cent improvement in the proposed building performance in a new building or a 5 per cent in a major renovated project (U.S. Green Building Council, 2014). It is also a requirement under LEED to have an on-site renewable energy source.

Providing electricity for housing in Saudi Arabia is one of the biggest challenges that is facing the country, where it is estimated that by 2050 energy demand in the Kingdom will be approximately 120 GW, and to meet this growing demand, 8 million barrels of oil per day will be required (Husain & Khalil, 2013). This high demand of fossil fuel will not only put stress on the Kingdom, but will also put stress on the whole world. Saudi Arabia was the world's largest producer and exporter of total petroleum liquids in 2012, and it was also the world's 13th largest consumer of total primary energy in 2009, of which about 60 percent was petroleum-based. In order to meet domestic power needs and to free up oil and natural gas for export, Saudi Arabia has set a goal of producing almost half of its power from renewable fuels by 2020. Having a sustainable and renewable source of energy is one of the methods to sustain the future for generations to come in the Kingdom specifically, and in the whole world in general.

For the past few years, the Kingdom of Saudi Arabia has been the highest per capita oil consumption country in the world. Daily oil barrel consumption equates to 4 million barrels and about 1.5 billion barrels per year, which is the equivalent to 48 barrels a year for every man, women and child. In comparison, the US consumes 9 barrels a year, and Japan consumes 5 barrels a year for the same individuals (Aluwaisheg, 2013). Not much has been done to preserve and conserve the use of Saudi Arabia's main source of income and to make things worse, there is no alternative transportation system other than the use of private transportation methods. Buildings account for the majority of energy consumption in all countries, but in Saudi Arabia "housing uses up nearly 80 percent of all electricity produced in the country, 70 percent of which is used for air conditioning alone" (Aluwaisheg, 2013). (Aluwaisheg, 2013) further states that there are two reasons for the over-consumption behavior occurring in Saudi Arabia. The first reason is because there are no strict laws to bind builders to use a certain type of insulation, which can contribute dramatically in the overall conservation of energy. The second reason is that laws are set to a very low standard when it comes to cooling systems used in buildings, which contributes to having high energy consumption levels.

Water scarcity is a reality in countries such as Saudi Arabia, where in 2009, it registered less than 90 cubic meters of renewable fresh water sources per capita. Figure 1 shows the levels of renewable water sources in the Gulf Co-operation Council (GCC) nations, where the severe water scarcity threshold stands at 500 cubic meters per capita per year. In 1980, Saudi Arabia consumed about 10 million cubic meters of water and it has increased significantly to reach 17.5 billion cubic meters in 2010, which corresponds to a 75 per cent increase (Samad & Bruno, 2013). For this reason, water conservation strategies are a must in buildings in Saudi Arabia for the continuation of fresh natural water resources in addition to non-natural water resources through desalination of seawater. According to the (Saudi Gazette, 2013) “In 2012, the Kingdom began operations at the world’s largest solar-powered water desalination plant in the city of Khafji, with a capacity of 30,000 m3/day”. This new plant will help the water scarce country to meet the high demand from the population and at the same time is powered by natural resource of energy.

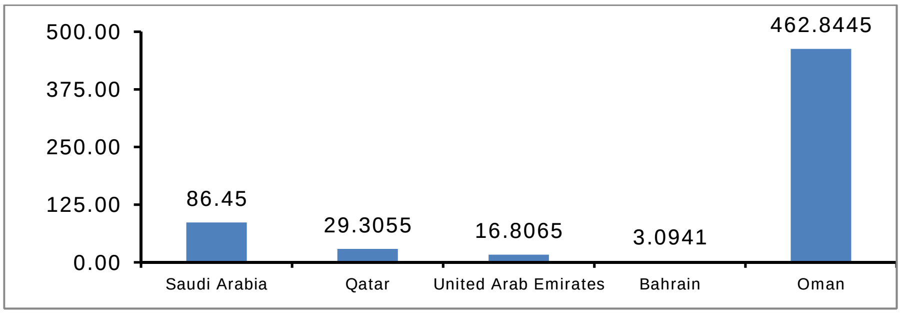

Figure 1 Renewable water resources in some of the GCC countries in 2011 (Cubic Meters) (The World Bank, 2013)

3. Research Method: Case Study Analysis

The data presented in this paper is based on three case studies from Saudi Arabia that have applied sustainable construction methods in their design. These three case studies are compared to a traditional residential building in Saudi Arabia that has not adopted sustainable construction methods. The comparison is to show the difference between applying sustainable construction methods to a residential building and to illustrate the benefits of applying sustainability. Case studies present us with new information by observing the case we want to analyze, “new knowledge is discovered by exploration by which we mean examining artefacts or situations or events. This is primarily achieved through observation, in the broadest sense of the word, and by reflection on what it is we are observing and by discussing this with knowledgeable informants and colleagues" (Remenyi, 2012).

Case study analysis is considered to be a qualitative approach to research. It differs from quantitative research due its nature of observing a case study in the field and interpreting data from the field to the research. "Methodologies used in the interpretivist paradigm are mainly qualitative rather than quantitative, and often involve field work – that is, study of the phenomena under consideration in their natural setting" (Oliver, 2004). Yin (2009) defines case study as "an empirical enquiry that investigates a contemporary phenomenon within its real life context, when the boundaries between phenomenon and context are not clearly evident, and in which multiple sources of evidence are used."

3.1 Non-Sustainable Case Study

King Abdullah University of Science and Technology (KAUST Industry Collaboration Program, 2013) has conducted studies on several types of buildings in Saudi Arabia and has analyzed those buildings in terms of two main aspects, i.e. energy consumption and water consumption. The report also discusses in detail how to preserve energy and water by promoting alternative passive design aspects and the use of certain technologies to reduce the overall amount of energy and water consumed. Figure 2 illustrates the typical layout and form of a house in Jeddah, which was the base of the analysis done by KAUST Industry Collaboration Program.

The house consists of two floors and it accommodates a family of five members. As a baseline for a typical Saudi house located in Jeddah, figures 3 and 4 illustrate the amount of energy consumed by the house if it was insulated and if it was not insulated. The total energy consumption (baseline) for a non-insulated residential building in Jeddah amounts to 1,044.6 kWh/m2 a year, of which 81.7% is used for cooling alone. Whereas, the total energy consumption (baseline) of an insulated residential building in Jeddah amounts to 588.4 kWh/m2 a year, of which 69.7% is used for cooling.

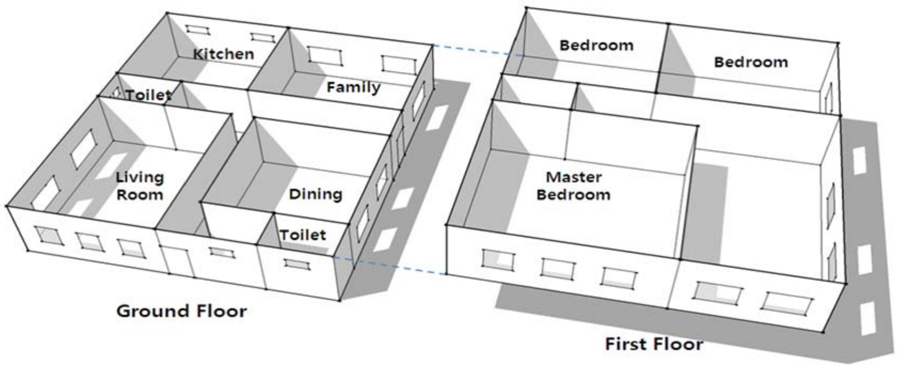

Figure 2 Layout and Shape of Typical Housing Unit in Jeddah (KAUST Industry Collaboration Program, 2013)

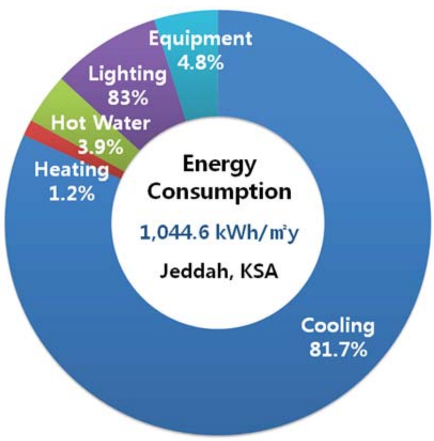

Figure 3 Energy Consumption of Housing Unit (non-Insulated House) (KAUST Industry Collaboration Program, 2013)

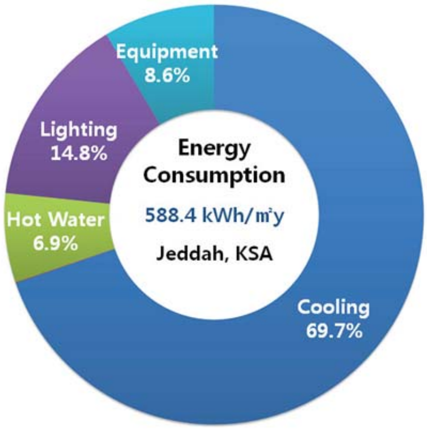

Figure 4 Energy Consumption of Housing Unit (Insulated House / Baseline) (KAUST Industry Collaboration Program, 2013)

To compare between sustainable and non-sustainable measures, Table 1 illustrates where it is possible to save more than 50 percent of the overall energy if sustainable measures are utilized, such as insulation that saves on energy consumption from the reduction in cooling loads.

Table 1 Primary Energy Consumption in Housing (Unit) in Jeddah in kWh/m^{2}y (KAUST Industry Collaboration Program, 2013)

Energy Type	**Sustainable Measures**	**Non-Sustainable Measures**
Cooling	410.3 (69.7%)	853.9 (81.7%)
Heating	0.3 (0.1%)	12.9 (1.2%)
Hot Water	40.4 (6.8%)	40.4 (3.9%)
Lighting	86.8 (14.8%)	86.8 (8.3%)
Equipment	50.6 (8.6%)	50.6 (4.8%)
Total	588.4 (100.0%)	1,044.6 (100.0%)

In comparing the water use and conservation percentage of water, Figure 5 illustrates the reduction rate if sustainable measures are utilized. The percentage of water reduction when utilizing sustainable methods such as water-saving devices for example, in faucets, showerheads and kitchen sinks can reach up to 49 percent. The installation of a water-saving device is the easiest way to reduce water consumption, but it incurs a cost burden upon the consumer. Providing government subsidies can offset this initial cost burden or other benefits such as incentives and grants.

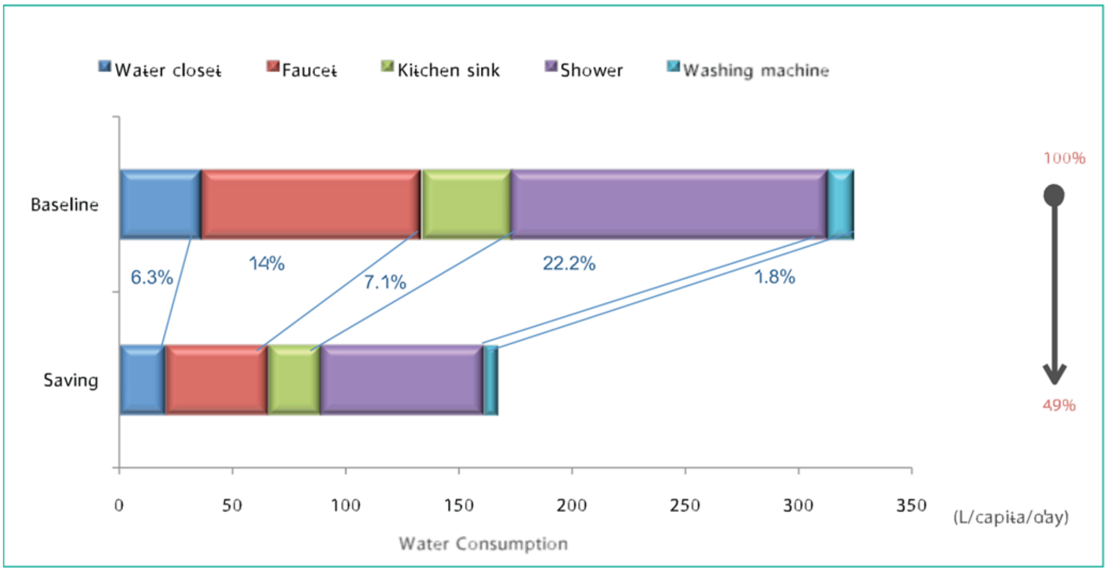

Figure 5 Reduction of Water Consumption by Saving & Reuse System (KAUST Industry Collaboration Program, 2013)

3.1 Sustainable Case Study

Sustainable projects are considerably new in Saudi Arabia and not many projects can be used as case studies due to their high security nature and lack of available sources. For the purpose of this paper, three residential building projects, which are in their pre-construction phase are analyzed as case studies. A design firm based in Beirut, Lebanon (named “The Other Dada”) is the designer of the three projects, which will be built in Saudi Arabia. The firm’s policy states that they believe in Sustainability as being a collaborative effort. The Other Dada's design process is organic, dynamic and interactive. The three residential building projects have total land occupancy of 5,850 square meters, they are:

- Fence House
- Doomsday House
- Landform House

This case study analysis will be looking at the projects from the following perspectives:

- Energy Consumption
- Water Consumption
- CO_2 Emissions
- Cultural Aspects
- Building Material

Table 2 lists the three case studies and their profiles in terms of Energy Consumption, Water Consumption, and CO_2 Emissions.

Table 2 Case Study Comparison (Dada, 2013)

Project		**Fence House**	**Doomsday House**	**Landform House**
Land Area		1250 m^2	1700 m^2	2900 m^2
Built-up Area		1000 m^2	1200 m^2	1800 m^2
Energy Consumption	**Baseline Consumption**	161 KWH/Year	161 KWH/Year	161 KWH/Year
	Design Consumption	136 KWH/Year	140 KWH/Year	117 KWH/Year
	Percentage Saved	15%	13%	27%
Water Consumption	**Baseline Consumption**	2900 L/Day	5200 L/Day	4800 L/Day
	Design Consumption	2200 L/Day	4000 L/Day	3700 L/Day
	Percentage Saved	29%	29%	29%

Project		Fence House	Doomsday House	Landform House
CO_2 Emissions	**Baseline Emissions**	153,000 KG/Year	199,000 KG/Year	232,000 KG/Year
	Design Emissions	117,000 KG/Year	170,000 KG/Year	165,000 KG/Year
	Percentage Saved	24%	15%	29%

The fourth element to analyze in the case studies is the cultural aspect. The three houses were designed to respect the unique culture of Saudi Arabia. For example, as we see in figure 6, the Fence House has implemented the courtyard typology of the traditional Saudi house as discussed in several literature references, including (Al Surf, Susilawati, & Trigunarsyah, 2012; AlGhamdi, 1995; Mahmud, 2009; North & Tripp, 2009; Sidawi, 2008), where the house looks inward onto a courtyard rather than outwards. This typology is common in Saudi Arabia because this design provides privacy for the residents due to having all the rooms of the house looking inward onto a courtyard. This feature has been carefully considered in the Fence House where the courtyard was designed to be a beautiful garden in addition to serving the function of privacy.

Figure 6 The Fence House (Dada, 2013)

The Doomsday House, figure 7, was designed in accordance with what the client asked for and that is to have a bunker-like house where he and his family can have shelter in case of emergencies or wars. The name of the house comes from the type of incident that may or may not occur, which is a doomsday event. The design of the house basically transformed the concept of the courtyard and the privacy issue and walled the southern and western walls so that no openings are found. In front of the house, from the eastern and northern sides, the house has a courtyard where the facades facing the courtyard have maximum exposure to daylight and the view of the garden. An integrated system of shutters allows the house to become totally impervious to the outside. The design includes a bunker that extends on two floors and that can shelter the whole family.

Figure 7 The Doomsday House (Dada, 2013)

The Landform House design, figure 8, has been approached differently because of the client's needs. The client requested the designer to respect the form of the land and design the house around it. This design feature promoted sustainability by preserving the current landform and not demolishing or excavating any unnecessary land. The house was designed in relation to the landform in three separate parts, public, private and service area. In traditional and historical buildings, landscape was a main part of the design of an Islamic background. This design feature gave the occupants a sensation of resemblance to paradise as foretold in the

Holy Quran. “Bustan” or “Jannah” as described in Holy Quran is a paradise that residents joyfully indulge in within the boundaries of their privately enclosed houses. The Landform House design accomplishes that by introducing a variety of landscaping features that are from the environment and provide a winding pathway between parts of the house. The Landform House, in addition to respecting the form of the land it is designed to be on, it respects the culture of the Saudi traditions by separating the public parts of the house from the private parts.

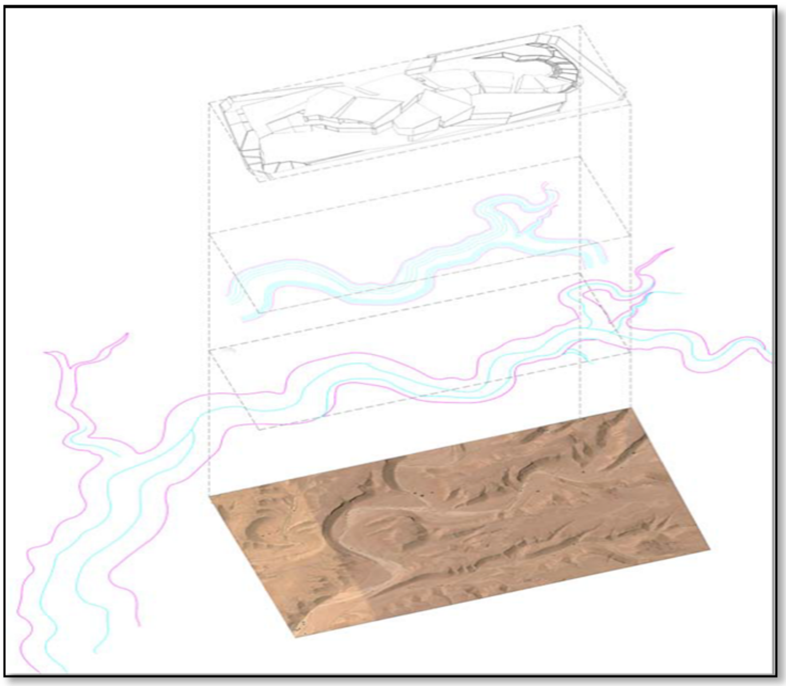

Figure 8 The Land Form House (Dada, 2013)

All of three houses were designed to use sustainable building materials such as Low-voc paints, no formaldehyde Glues, locally sourced materials whenever possible, mineral wool insulation, including 30% of Pozzolan material in the concrete mixture, and photocatalytic concrete. These building materials, in addition to the other methods and techniques used, will increase the amount of energy saving which will reduce the overall impact on the environment.

4. Discussion

From the case studies, it is evident that utilizing sustainable measures is a must for the survival of Saudi Arabia's natural resources and to conserve on the load it puts on the global scale. It has been shown that the majority of energy consumed in residential buildings in Saudi Arabia, over 80 per cent, is due to cooling the indoor environment. Designing buildings that account to permitting daylight and reducing direct sunlight will evidently reduce the cooling load and reduce the energy consumption overall. Selection of certain building materials that are environmentally friendly is crucial to reducing the Heat Island Effect. Design elements can be largely divided into architectural technologies (a passive method) and equipment-related approaches (an active method). The use of the two architectural design methods can help reduce the overall consumption of energy and help improve the environment.

In Table 2, the amount of energy and water consumption in addition to the amount of CO_2 emissions was illustrated. Energy saving in the Landform house reached 27 per cent when sustainable measures were incorporated into the design. Water consumption saving reached 29 per cent across all houses, which mean that water consumption, can be greatly reduced, and high saving percentages can be easily achieved if sustainable methods are used. CO_2 emissions can also be greatly reduced where the Landform house had a great CO_2 emission reduction by 29 per cent, which equates to 67,000 Kilograms per year.

In Figure 3 shows that the remarkable increase in cooling loads, reaching more than 80 per cent due to lack of insulation, can quite heavily put a burden on the energy production in Saudi Arabia. This case is true because, as discussed earlier in this paper, there are no strict laws to bind builders to use a certain type of insulation, which can contribute dramatically in the overall conservation of energy. In contrast, the same housing unit registered a reduction in cooling load simply by adding appropriate insulation (Figure 4). From this data, it is evidently crucial that the Saudi government must put strict laws on the types of insulation that should be used and other laws have to be applied to promote the use of sustainable methods to come to the overall reduction in consumption of energy and water.

"The average amount of water consumption in KSA is 325 L/capita/day, the third-highest after the U.S and Canada. The average discharge of easily recyclable gray-water amounts to 288 L/capita/day, or 89% of total consumption" (KAUST Industry Collaboration Program, 2013). This water consumption level is extremely high when taking into account that Saudi Arabia is considered to be a water scarce country with an annual renewable water resource of 86.45 cubic meters (The World Bank, 2013). The easiest way to reduce water consumption is by the installation of a water-saving device, but it incurs an initial cost burden on the consumer that can be offset if the government provides subsidies or other benefits to reduce the initial cost for the benefit of the long-term cost savings and water conservation. In the baseline water consumption case study done by (KAUST Industry Collaboration Program, 2013), Showers and faucets account for 43% and 30% of water consumption, respectively, considerably higher than for other outlets. This suggests that by installing a gray-water collection system, water can be 100% reused for toilet use and selected cleaning.

5. Conclusion

This paper has discussed the effect of rapid urbanization on the built environment of Saudi Arabia, and the stress it puts on the local infrastructure, which leads to more consumption of the world's natural resources. Preservation of natural resources can be achieved through the application and adaptation of sustainable construction methods. Developing countries are still under development and that gives them the advantage of applying the concepts and applications of sustainability while projects are still under development.

This paper concludes that the use of sustainable construction methods in Saudi Arabia is a necessity for the survival of the country's natural resources. The Saudi government should promote the use of sustainable technologies, such as water-saving devices for example, in faucets, showerheads and kitchen sinks where consumption reduction can reach up to 49 percent. Energy saving techniques must be applied in housing in Saudi Arabia, where this paper has shown that an overall reduction in energy consumption can reach more than 50 percent.

This paper research method has been conducted on three case studies that are in the design phase, and as such, it is recommended that future research and analysis are done on constructed residential buildings to evaluate the effectiveness of utilizing sustainable methods and validate the outcomes of this paper. Saudi Arabia is strongly moving towards implementing sustainable and green construction methods, but more data is needed to convince the public and the government of the necessity of applying them now while the country is still under rapid development. It is also recommended that Saudi stakeholders get involved to reduce red tape to help hasten the application of sustainability on current construction and future ones as well. Finally, mandating new laws by the Saudi Government to reduce the overall consumption of energy and water to reduce the depletion of natural resources is a major outcome.

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